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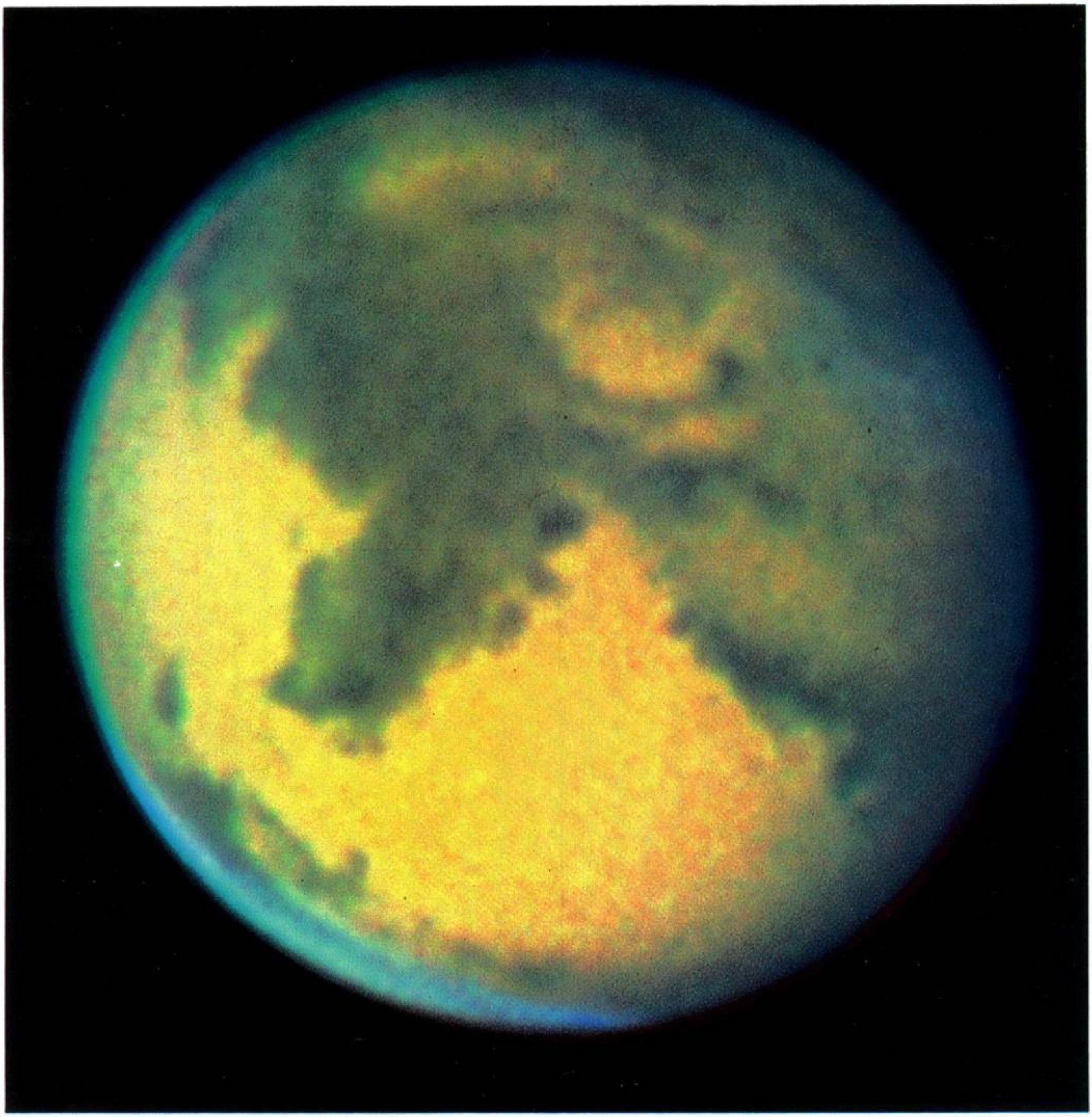

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■ Under highly controlled "perfect seeing" laboratory conditions, each 3-element SC optical set—prior to being installed into its optical tube—is tested in a laser autocollimator at an effective power of 1000X. Diffraction images are examined for roundness, regularity, and consistency inside and outside of focus.

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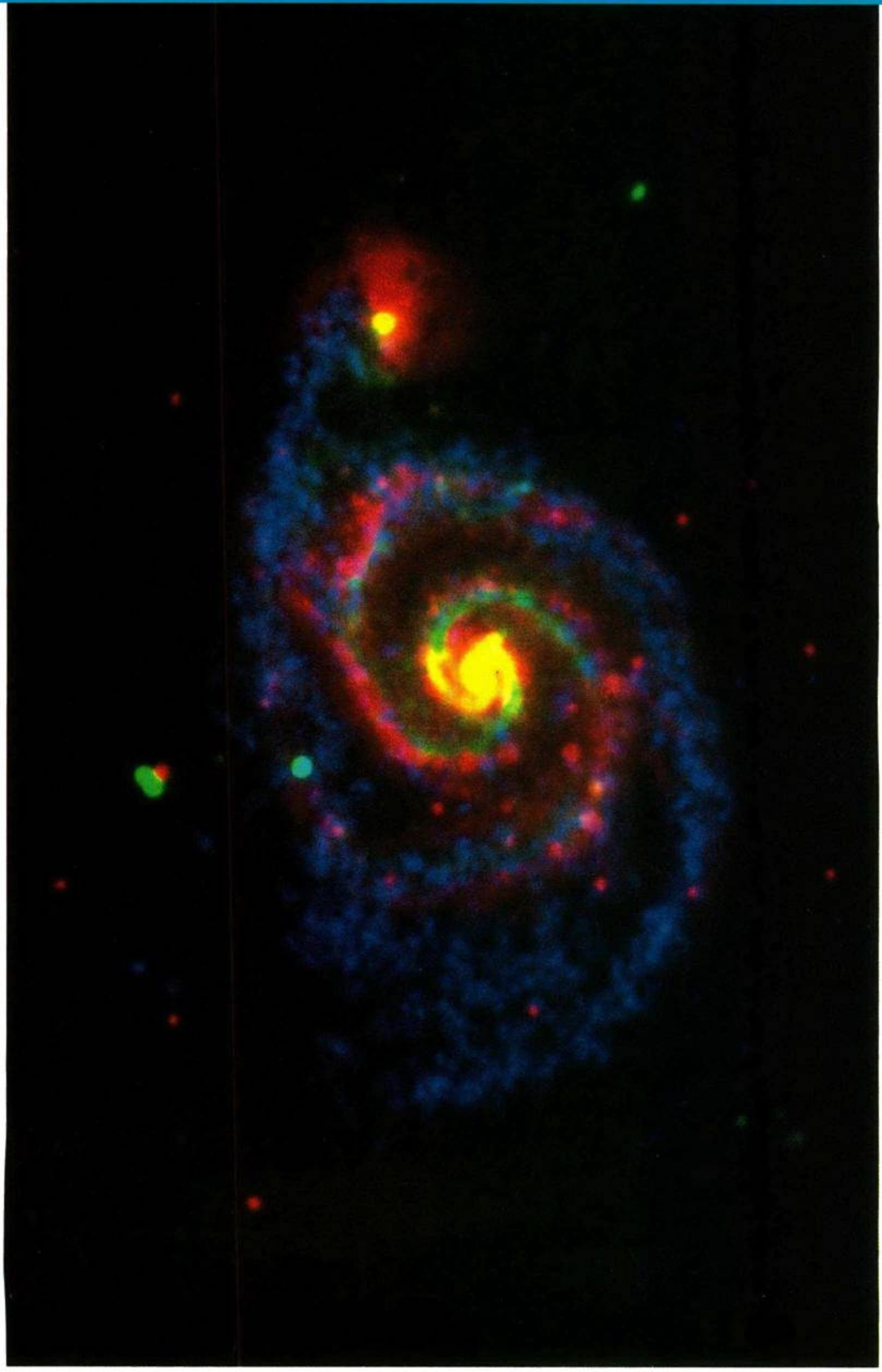
ON THE COVER:

The Hubble Space Telescope took this high-resolution image of Mars last December when Mars was near Earth. For other recent Hubble results, see page 44. Phil James, University of Toledo, and NASA.



THE SUBTLE SPIRALS OF SPRING are a favorite target for backyard telescopes. This image of M51 in Canes Venatici combines an optical image (red) showing young stars and dust, a radio image (green) revealing ionized *hydrogen regions and* synchrotron radiation, and an image of 21cm spectral-line emission (blue) showing the distribution of neutral hydrogen. NRAO/AUI image.

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ASTRONOMY (ISSN 0091-6358) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Telephone: (414) 796-8776, weekdays, 8:30 a.m.-4:45 p.m. Subscription inquiries: (800) 446-5489. Copyright ©1991 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission. Second-class postage paid at Waukesha, WI, and additional mailing offices.. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with the current issue. Subscription price: 1 year, $24. All foreign: add $9 per year; please remit in U.S. funds. GST #R122713209. Send editorial and business inquiries and submissions to the address above. Not responsible for unsolicited materials. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature.* Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 North Zeeb Road, Ann Arbor, MI 48106. Printed in the U.S.A. **POSTMASTER**: Send address changes to ASTRONOMY, 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Canadian second-class postal permit no. 545775.

The Audit Bureau

Behind the Scenes

ASTRONOMY AND ASTRONOMY CLUBS

Do you belong to an astronomy club? According to our most recent survey, about 20 percent of ASTRONOMY's readers do. So about 80 percent of you are missing out on one of the best aspects of amateur astronomy.

Bound into the center of this issue of ASTRONOMY, you'll find our annual Guide to Astronomical Activities. Check out the comprehensive listing of astronomy clubs and astronomical societies (same thing really!) that will enrich your enjoyment of your hobby.

Clubs are a centerpiece of the Guide because they're really the spark plugs of amateur astronomy, places where people interested in astronomy gather, meet each other, and learn more about astronomy together.

Astronomy clubs are spark plugs because they get people working together. Within their communities, they create public awareness of astronomy. Their monthly meetings, group activities, and star parties attract new people to the hobby of astronomy.

"So," you may be thinking, "what's in it for me?" Well, that depends on your local club. If the group owns an observatory, you may gain access to a large telescope. At meetings you'll hear lectures by astronomers. You'll have the opportunity to take field trips to observatories, go observing at club star parties, and share your astronomical interest with other people.

You may also be able to get ASTRONOMY at low club rates as a benefit of club membership. Today, in fact, more clubs offer ASTRONOMY to their members than any other magazine. Of course, we're pleased to know that ASTRONOMY is tops with astronomy clubs.

Perhaps the most clear-cut role of astronomy clubs is public awareness and public education. Each spring, on Astronomy Day, millions of people get to see astronomy in action. Through public star parties, exhibits, booths, and displays at shopping malls, the public sees books, posters, telescopes, and — the most important ingredient — people who are interested in astronomy.

That's what makes astronomy clubs so great. They let people know "Yes, you can do it. We're doing astronomy, and you can too. Come join us." If you're already a member of an astronomy club, what you most value is the fellowship you've found in the club.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

P. S. I'd like to thank all the clubs, planetariums, and observatories that responded to our annual survey. If we missed you this year, please send us current information right away so that we can be sure to include you in next year's Guide to Astronomical Activities.

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U.S. Newsstand Distribution
I.C.D., The Hearst Corp., New York, NY 10019
Canadian Newsstand Distribution
Telemedia Dist., Toronto, Ontario M4S3B3
World Newsstand Distribution
Curtis Circulation Co., Hackensack, NJ 07601

Letters

Shoot for the Stars

As one of the five amateurs to win time on the Hubble Space Telescope, I would like to encourage your readers to submit research ideas to the Hubble working group. When I started the application process a few years ago, I thought I would not stand a chance of being accepted because I had never taken an astronomy course and had studied only biology in college.

My journey through library research, the application process and then writing the proposal was an amazing adventure. The staff at the Space Telescope Science Institute supplied me with a great deal of information, and even guided me through writing the proposal in language suitable for their computers!

I suggest that anyone interested in proposing a project for HST should first contact the American Association of Variable Star Observers, 187 Concord Avenue, Cambridge, Massachusetts 02138. They can supply readers with information and applications for HST proposals. — *Jim Secosky, Manchester, New Hampshire*

Daytime Venus

I was glad to read in your magazine that readers have spotted Venus during the daytime. When I lived in New Mexico the clear, dry air and a 4,000-foot elevation made seeing Venus during the day relatively easy. I'm in Virginia now and Venus is a real challenge at sea level, with high humidity and lots of clouds.

Recently while awaiting the Scotland-Jamestown Ferry, I spotted Venus through binoculars and then was able to see it without optical aid. Another passenger was amazed when I pointed out the planet to her. If you haven't seen Venus during the day, try it — you'll dazzle your friends and neighbors. — *William L. Taylor, Seaford, Virginia*

'Twas Only a 60-incher!

I greatly appreciated seeing a photo published in ASTRONOMY's "Reader Reports" made by me and my students from the Arizona Astronomy Summer Camp (February 1991 issue). However, the caption incorrectly stated that the shot was made with the 90-inch telescope at Steward Observatory on Kitt Peak. While we toured this facility this year, the photo was made with the 60-inch reflector — a mere shade of the giant 90-incher — on Mount Lemmon near Tucson. — *J. Davy Kirkpatrick, Steward Observatory, University of Arizona, Tucson, Arizona*

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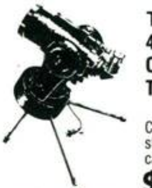

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Deluxe Latitude Adjuster: 2045, 2080, 2120	$25
Setting Circle Illuminator System: 2080, 2120	$36
L.E.D. Map Light: 2045, LX3, 2080 LX3, 2120 LX3	$26
#605 Magnetic Compass	$10
#607 25' Extension Cord for use with AC Converter	$16
Azimuth Control (for Field Tripods for Model 2080)	$20
#603 DC Cord (25') w/cigarette plug	$16
#604 AC Converter w/25' Cord	$26
#784 Qtz. Drive (GEM)	$349
#1200, 1200A Electric Focuser	$195
#671 Wide-Field Adapter System (WFAS complete)	$98
Tele-Compresser Lens only	$39
Tele-Compresser System comp. w/Extender Tube	$54
Eyepiece Extender Tube only	$18
Off-Axis Guider Body only	$65
Off-Axis Guider Assembly comp. w/illuminated	$129
#419/#427 Illum. Ret. Eyepiece System .965", 1.25"	$78
#702A Double Crossline Reticle	$24
#705A Micrometer Reticle	$26
Spotting Scope adapter Plate: 2080, 2080 LX3, 5 & 6	$40
H35mm Crosshair Eyepiece (.965) R9MM	$36
Spotting Scope Adapter Plate: 2120, 2120 LX3, 5 & 6	$52

Mod. Ach. (.965) 9, 12, 25, 40mm	$34
40mm Mod. Achromatic ep., 1.25"	$39
.965 Orthos 4mm, 6mm, 9mm, 18mm Oculars	$39
1.25" Orthos 4mm, 6mm, 9mm, 12.5mm & 18mm	$46
Sup. Plossl 1.25"	
6.4mm, 9.7mm, 12.4mm, 15mm, 20mm & 26 Oc	$64
32mm, 40mm, 1.25"	$82
56mm, 2"	$156
13.8mm Super Wides 1.25"	$106
18mm 1.25"	$114
24.5mm 1.25"	$119
32mm 2"	$179
40mm 2"	$249
4.7mm 1.25"	$119
6.7mm 1.25"	$144
8.8mm 1.25"/2"	$172
14mm 1.25"/2"	$198
Rotary Multiple Holder 1¼	$124
Eyepiece Holder, 1.25"	$26
#915 Diagonal Prism .965	$36
#917 Hybrid Diagonal Prism (.965/1.25)	$36
#918 Diagonal Prism 1.25"	$36
#919 Diagonal Prism w/threaded Ring 1.25"	$40
#929 2" Diagonal Mirror including eyepiece adapter w/1¼" Adapter	$135
#930 2" Diag. Mirror, 2" OD Barrel for 2" Focuser Sleeve	$119
#926 Image Erecting Lens (220, 226)	$19.50
#924 Erecting Prism 1.25"	$56
#928 Erecting Prism System 45°	$46
#912 Roof Prism .965 90B, 97D, 97E, 97ER	$66
#928 Erect-Image Roof Prism	$42
#931 Hybrid 45° Erecting Roof Prism	$49
Photo Visual Color Filters & Polarizer .965", 1.25" All Col. Avail	$11.50
Set of 6 Photo Visual Color Filters (#8, 23A, 58)	$68
Set of 6 Photo Visual Filters (.965) Thread In	$68
Series VI Drop-In Filter Set 102, 107D	$49
Series V Drop-In Filter Set 90B, 97D, 97E, 97ER	$46
#905 Variable Polarizing Eyepiece System 1.25"	$48
Nebula Filter #908 1.25	$58
#910 Nebula Filter 2"	$102
Electronic Control Center	$229
#911 Nebula Filter (rear cell Thread on)	$98
#122 2X Tele-negative Amplifier (for all 8" & 10")	$40
#126 (2045), 1¼" Barlow	$39
#127 2X-3X Variable Tele-negative Amplifier	$54
#131 2X Tele-negative Amplifier .965 (291, 294)	$36
#140 2X Tele-negative Amplifier (for all 8" & 10")	$62
#581 Sun Shade 90B	$46

#582 Dew Shade for 107D, 2045	$46
#710 Dew Shield 10", 2120	$104
#712 Dew Shield 8", 2080	$89
#1A Skylight Filter/Dust Seal	$44
#50 Accessory Case	$59
Extra 2lb Weights for 1401 or 1402 each	$20
#1401 Tube Balance Weight System 2080	$77
#1402 Tube Balance Weight System 2120	$82
Extra Counterweight 25lb. 880, 1060, 1266	$66
Extra Counterweight 40lb. 880, 1060, 1266	$86
#300 PG 3.1" Photo-Guide Telescope	$286
#280 PG 2.4" Photo-Guide Telescope	$126
#67 Focuser 1.25" I.D.	$46
#640 Focuser 1.25" I.D.	$72
#680 Deluxe Focuser 1.25" & 2" I.D.	$94
#59 Photo Adapter Pathfinder only	$18
#60, #62, #61, T-Adapters	$24
#64 T-Adapter only, for WFAS	$34
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Prime Focus Camera Adapter (277)	$20
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#708 Piggyback Camera Adapter (310, 320)	$36
Piggyback Bracket: 2080/2120	$30
Piggyback Bracket: 2045, 2045LX3	$16
#630 6x30 Right Angle Viewfinder	$42
#631 6x30mm View Finder w/bracket	$42
#967 9x60 Polar Illuminated View Finder w/bracket	$142
Bracket for #541 View Finder	$12
#634, 6x30 View Finder w/bracket — MTS 6-8	$42
#541 5x24 R/A View Finder	$45
#544 8x50 View Finder w/bracket — SC8	$76
Mounting Brackets (2.38") or (3.6" I.D.)	$28
#781 Electric Motor Drive, AC (323, 4420)	$89
#787 Electric Motor Drive System (DS-10)	$96
#897 Electric Motor Drive System (DS-16)	$187
#55 Manual Declination Control 628C, 645C, 826C	$69
#65RS Manual Declination Control 880, 1060, 1266	$106
#48RS Dual Axis Drive Corrector System 880, 1060	$369
#36 Single Axis-Dual Axis Drive Corrector Control	$82
#38 Declination Motor Assembly 2080LX3, 2120LX3	$82
Electronic Control Center	$229
#43 R.A. Drive Corrector operates from 12VDC	$82
#46 Dual Axis Drive	$259
#47M Dual Axis Drive Corrector System 628C, 645C	$294
#388 Declination Motor Assembly 2080, 2120	$84
#38M Electric Declination System	$74
#39 Declination Motor for LX5	$84
#66A Manual Declination Control	$42
#66C Manual Declination Control	$54
#56 Declination Control	$99

Casters (2" Diameter) for DS-16 (set of 3)	$38
Leveling Screws for DS-16 (set of 3)	$38
Leveling Screws for DS-10 (set of 3)	$29
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Setting Circles for DS-10: 3" Diameter w/pointer	$30
Setting Circles for DS-16: 6" Diameter w/pointer	$56
Vinyl Dust Cover for DS-16	$26
Vinyl Dust Cover for DS-10	$19
Lens Caps — .96, 1¼	$.50 EA (7 for $3)
Vinyl Dust Cover pair 6" (628C, 645C)	$26
Vinyl Dust Cover pair 8" (826C, 880), 10" (1060)	$36
Accessory Shelf for DS-10	$39
Accessory Shelf for 880, 1060, 1266	$49
Accessory Shelf for Field Tripod (2045, 2080, 2120)	$24
#AD-1 Eyepiece Adapter .965, #AD-2 1¼"	$18
Mirror 16" f4.5	$895

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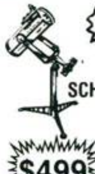
TELESCOPES

2045D...$608 Carry Case...$68

NEW "Smart Drive" "PPEC" Units

	40	46	50	56	70	76
2080 2120	**CALL!**					

SUPER VALUE



**MTS-SN6
SCHMIDT-NEWTONIAN
6" & 4.5**

"BEST BUY"

$499

(The complete MTS Series is obsolete; these units are going fast!)

THIS MONTH'S SPECIALS

$18 EACH

T-ADAPTER TELE-EXTENDER

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Telescope-Accessory Catalog/Data Pack (2lbs) $10.00 Refundable
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3% credit charge

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C6 O.T. Assy. (Demo)
Unitron 5" (f15)/Cave Cas.8" (f15)
Telesscopics 12½" 8800 (f5) 8"/SPC8

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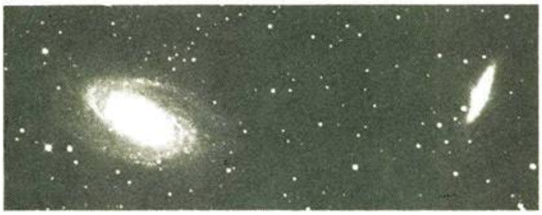
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH



Galaxies M81 (left) and M82 (right) in Ursa Major. 30 minute exposure by Martin Germano using 103aF, and an 8" f/5 telescope with a LUMICON 2" Newtonian EASY-GUIDER. Visually M82 shows much mottling and detail. Spiral detail in M81 is hard to see visually.

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK!

Oracle 3" f/7.4 Triplet Apochromat	$750
Genesis 4" f/5 4 element fluorite	$1450
Renaissance 4" f/5.5 refractor	$1450
Complete Equatorial Mount	$795
Motor Drive for above mount	$198
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$89
1.8x or 2.5x Tele Vue Barlow Lens	$89
2" Giant Barlow	$219
32mm Plossl, widest true field in 1¼"	$109
55mm 2" Plossl, widest possible field	$219
15mm Wide-Field, 1¼" eyepiece, 65°	$135
19mm Wide-Field, 1¼" eyepiece, 85°	$145
24mm Wide-Field, "superb," 65°	$169
32mm Wide-Field, 2" eyepiece, 65°	$239
40mm Wide-Field, "awesome," 65°	$299
4.8mm Nagler, 82° field	$149
7mm Nagler, 1¼" eyepiece, 82° field	$189
9mm Nagler, 82° field, "the best"	$219
11mm Nagler, 82° field, 1¼" or 2"	$235
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$289
20mm Nagler, Type II, 82°, 2" only	$340
1¼" Paracorr Visual Coma Corrector	$179
2" Paracorr Visual Coma Corrector	$298

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount .. **$54**
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	**H-Alpha**	**(MV)**
46, 48, 49mm	**$47.00**	**$39.00**
52, 55, 58, 62mm	**$59.00**	**$49.00**
67, 72, 77mm	**$69.00**	**$59.00**
82mm	**$79.00**	**N/A**

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. 1.3-1.8" mirrors have enhanced silver coatings (98-99%R). The extra 8-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$29.95** 1.52" **$34.50** 1.83" **$39.50**
2.14" **$49.50** 2.60" **$65.00** 3.10" **$89.50**
4.25" **$149.50** 4.00" **$149.00**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$159.00**

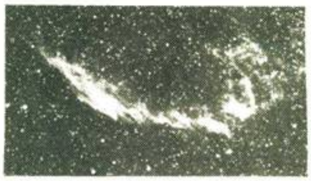
LUMICON FILTERS STOP LIGHT POLLUTION

UHC Filter™

ULTRA HIGH CONTRAST

The **LUMICON UHC FILTER** is specially designed for visual astronomy in areas of severe light pollution or for viewing very faint nebulae at any location. **UHC** stands for **U**ltra **H**igh **C**ontrast and this filter is guaranteed to yield a higher visual contrast on planetary and emission nebulae than any other filter at any price. 24nm visible bandpass, 482-506nm. Transmission = 90-97%.

For optimum astronomy, use either the **LUMICON DEEP-SKY Filter or the LUMICON UHC Filter**



"I CAN SEE THE VEIL NEBULA!"
Rich Zepernick saw the Veil Nebula for the very first time with a LUMICON UHC Filter. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6x contrast gain for nebulae and 1-3x contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass. 442-532nm. H-Alpha 656nm transmission = 85-95%. Visible transmission = 85-95%.

	Premium*
0.96" **LUMICON DEEP-SKY Filter** threads into most 0.96" eyepieces	**$59.50**
1¼" **LUMICON DEEP-SKY Filter** threads into most 1¼" eyepieces	**$79.50**
48mm LUMICON DEEP-SKY Filter (1.75" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	**$119.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$119.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	**$299.50**
1¼" **LUMICON UHC Filter** threads into most 1¼" eyepieces	**$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	**$199.50**
Set of Both premium **DEEP-SKY** and **UHC Filters** (Save 11%), Premium	**$159.50**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** **$99.50, 48mm**	**$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines **1¼" $99.50, 48mm**	**$199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	**$6.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	**$16.00**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	**$20.00**

**Premium filters are selected best of the lot and typically have 5-10% higher transmission. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

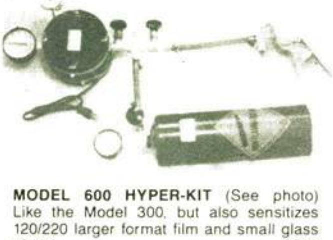
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$295**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.
U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$169.50**
3X Relay Diagonal (see photo)	**$89.50**
Illuminated reticle eyepiece system	**$99.50**
Guider for Hasselblad **$350**, Mamiya 645	**$199**
Adapter for Pentax 6x7 med. format	**$89**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER	**$225.00**
Adapter for Hasselblad **$185**, Mamiya 645	**$159**

GIANT EASY-GUIDER™

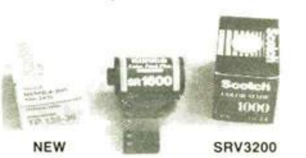
For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER	**$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20)	add **$99.95**
Adapter for Hasselblad **$195**, Mamiya	**$96**

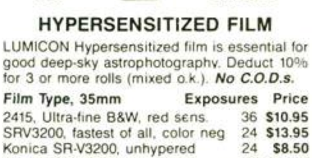
WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**



3. **LUMICON Quartz Drive Corrector** . **$219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
Declination motor (state telescope) .. **$99**
NEW Deluxe Digital Qtz. Drive Correc. **$298**



HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SRV3200, fastest of all, color neg	24	**$13.95**
Konica SR-V3200, unhypered	24	**$8.50**
Konica SR400, fine grain color neg	12	**$10.95**
3M 1000, fastest slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

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IMPROVED LUMICON® SKY VECTOR II™ $589

Now 1500 of "Best" Deep-Sky Objects in Computer Memory

LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- Digital right ascension readout to 1 minute of right ascension (RA)
- Digital decl. readout to 10 arc-min
- 4000 pulse (0.09° accuracy) high resolution encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, date, sidereal time, etc.
- 9V Battery lasts many nights.

Each LUMICON SKY VECTOR™ includes one computer with digital readout, two precision high resolution digital shaft encoders, connecting cables, & mounting hardware (for most popular telescopes). **Specify telescope.**

LUMICON SKY VECTOR™ for Meade 2080, Meade 2120 *(Specify)*	**$399**
For Celestron C-8, C-11 *(Specify)*	**$399**
For Coulter Odyssey 8", 10", 13", 17½"	**$399**
For any alt-azimuth (Dobsonian) scope	**$399**
For Celestron C-14 (rewire dec. motor)	**$498**
SKY VECTOR KIT (for skilled ATM's)	**$369**

Reference catalogues (1000's of objects)	
Burnham's *Celestial Handbook*, I, II, III	**$36.85**
Revised New General Catalogue (all NGC and IC, Epoch 1975.0)	**$35.00**
Sky Catalogue 2000.0, Vol. II	**$29.95**

Only the LUMICON SKY VECTOR II has size, true **visual** magnitude, and complete **visual** appearance description for **all** 1500 objects in memory.

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MODE
STAR
UP
DOWN
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COMPUTER SETTING CIRCLES
LUMICON®

LUMICON SKY VECTOR II™ Computer with 1500 object memory, digital readout of coordinates, easy-to-use controls, object size, visual magnitude and visual appearance descriptions.

Please specify telescope type:

LUMICON SKY VECTOR II™ for Meade 2080, Meade 2120 (*Please specify*)	**$589**
For Celestron C-8, C-11 *(Specify)*	**$589**
For Celestron C-14 (rewire dec. motor)	**$665**
For Coulter Odyssey 8",10",13"17½"	**$589**
For any alt-azimuth (Dobsonian) scope	**$589**
SKY VECTOR II (upgrade, computer only)	**$395**

The **LUMICON SKY VECTOR II**™ has all the features of the regular SKY VECTOR, but has 1500 of the best deep-sky objects in memory, selected by noted observer Steve Gottlieb, along with their coordinates, size, true visual magnitude, and other descriptive data. The sophisticated computer programming also will guide you to the object selected by displaying the real-time angular separation. Just move the telescope until the angles displayed become "0" using the "GUIDE" mode.

LUMICON SKY VECTOR II FEATURES:

- Includes **size, true visual magnitude & complete visual appearance description** for all 1500 objects
- All 110 Messier objects
- Brightest 31 alignment stars
- User definable catalogue of 25 objects retained in memory
- 703 galaxies, groups & clusters
- 228 best open star clusters
- 170 best planetary nebulae
- 77 emission & reflection nebulae
- 10 best dark nebulae
- 107 best gobular star clusters
- 205 best colored & multiple stars
- Displays Uranometria 2000.0 chart no.
- ROM upgradable for planets, extended object lists, etc.
- TIMER function, elapsed time & stop watch
- 2 star alignment for alt-azimuth or equatorial telescope systems
- 1 star alignment if polar aligned
- Uses Epoch 2000.0 coordinates
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New Society for Double Star Observers

I'm happy to announce the formation of the Association of Binary Star Observers (ABSO), a group of amateur astronomers interested in observing and photographing double star systems. As the only such society in existence, we intend to provide members with information on how to make double star measurements, suggest ways our members can have their data used and published by professional astronomers, provide a means for double star observers to get to know each other, and keep all members informed of news through our publication, *Binary Star*.

Observers interested in discovering more about our group should write me at their convenience. — *Ronald C. Tanguay, Director, Association of Binary Star Observers, 306 Reynolds Drive, Saugus, Massachusetts 01906*

Will the Best 6-inch Scope Please Stand Up Now?

In addition to "Will the Best 6-inch Scope Please Stand Up?" (Letters, January 1991 issue), I would like to include one that you missed, the Meade 6600 6-inch f/5 G.E.M. reflector. I have owned one for two-and-a-half years and have found it to be an excellent telescope. Optically it competes with the 8-inch and 10-inch SCTs, yet it weighs only 50 pounds, so setup is a snap. The value of the f/5 system can't be beat.

Unfortunately Meade stopped making the 6600 a short time ago. Why? Was it too competitive with their own more expensive models? — *Barbara Crain, Saugus, California*

— *We've heard from other amateurs praising the Meade 6600. It's unfortunate that 6-inch Newtonians, once the mainstay of the amateur market, have now become nearly extinct. If it is well made, a classic 6-inch Newtonian can be a wonderful and economical all-purpose telescope.*

It Came from Outer Space!

I greatly enjoyed reading your article on meteors, "It Came from Outer Space!" by Christopher Spratt (February 1991 issue). However, I was disappointed that in the sidebar on organizations that collect fireball data, you didn't include the Fireball Data Center (FIDAC) of the International Meteor Organization (IMO). This group is run by Andre Knofel, Anton-Fischer-Ring 96, DDR-1580, Potsdam, Germany.

The FIDAC not only collects data on fireballs, but also uses what it collects. The IMO has published a report of visual and fireball observations for 1988; a report for 1989 should be available soon.

I would be happy to supply more information on the IMO or supply copies of forms for reporting fireballs if readers are interested. — *Philip A. Roberts, Jr., 9661 Ironbridge Road, Chesterfield, Virginia 23832*

The beautiful sketch of a meteor over Stellafane brought to mind a vivid memory of the most spectacular fireball I've ever witnessed. At the time, I was not on Breezy Hill as depicted by the sketch but a mile or so down the hill in the Stellafane campground.

The date was August 5, 1973. Some time after midnight I was loading film into my camera with my back to the north when suddenly everything around was bathed in a silvery glow. My first thought was that someone had turned on car headlights, but in an instant I saw that the entire camping field was illuminated. Because my eyes were previously dark-adapted, the field seemed to glow as bright as daylight for a few long seconds.

I turned in time to see a brilliant ball of light descending above the treetops in the northern sky. After a few seconds, the fireball passed behind the trees but its light continued to be visible through the branches. The entire event lasted about ten seconds and caused an eruption of shouts and cheers from the hundreds of observers still outside at that hour.

The "Springfield Fireball" was later described in a report published by the Smithsonian Institution's Center for Short-Lived Phenomena. The estimated magnitude was -16! — *Richard H. Sanderson, Monson, Massachusetts*

I was greatly pleased to see the photograph of the famous northwestern fireball of 1972 in your article. I was eyewitness to that event and remember it vividly. On August 10, three friends and I were east of Spokane, Washington and watched this incredibly bright object cross the sky over the Spokane Valley. — *Joel Carr, Mica, Washington*

Contrary to what most observers think, you don't necessarily have to be outdoors to see a fireball. On the evening of April 25, 1966, I was reading at home in Boston and happened to glance out the window in time to see what appeared at the instant to be a ball of flame trailing sparks as it plowed across the sky in a low horizontal line.

The newspapers later reported that this bolide passed due northward over the entire northeastern seaboard, where it was extensively photographed and even filmed. It was ultimately honored by having still frames and photographs of itself published in *Life* magazine (May 6, 1966), having been seen by (possibly) more people than any other meteor in history. — *Joe Becker, Palo Alto, California*

The Earth All Alone

I was dismayed at reading "The Earth without the Moon" by Neil F. Comins (February issue).

The article started with an interesting premise. I was amazed at the author's assertion that the Moon served as a shield against meteorites. This argues against mathematics. By my calculations, the Moon probably intercepted something like 1 percent of them. Some protector of life! — *Evan Jones, Atlanta, Georgia*

I found the Moonless Earth quite interesting and enlightening but have a bone to pick with the author. He states that the orbital period of the Moon and Earth's period of rotation will eventually be the same. The author postulates the mechanism for this as tidal interaction. Curious as to what Earth's rotation period would be if the Moon comes to rest in a fixed point in the sky, I dug out my old physics text and began to calculate.

Assuming that the sum of the angular kinetic energy of Earth, the potential energy and the kinetic energy of the Moon are constant, the Moon's orbital period would always be greater than Earth's rotational period. In fact, boosting the Moon into higher orbits always slows the Moon much more than Earth.

If Earth's angular moment of inertia were 1/10 or less of its present value, then the author would be correct. Earth would slow down and synchronization might occur. — *Mike Flegal, Calgary, Alberta, Canada*

Correction

On page 90 of the March 1990 issue, the price of the Orion Telescope Center's SpaceProbe 4.5 reflector should read $399, not $339. The price range for the Orion UltraScan eyepieces should read $99 to $199, not $99 to $139. ☐

ASTRONOMY welcomes comments, suggestions, and additional information on articles and astronomy in general. Send your letters to: ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length or clarity.

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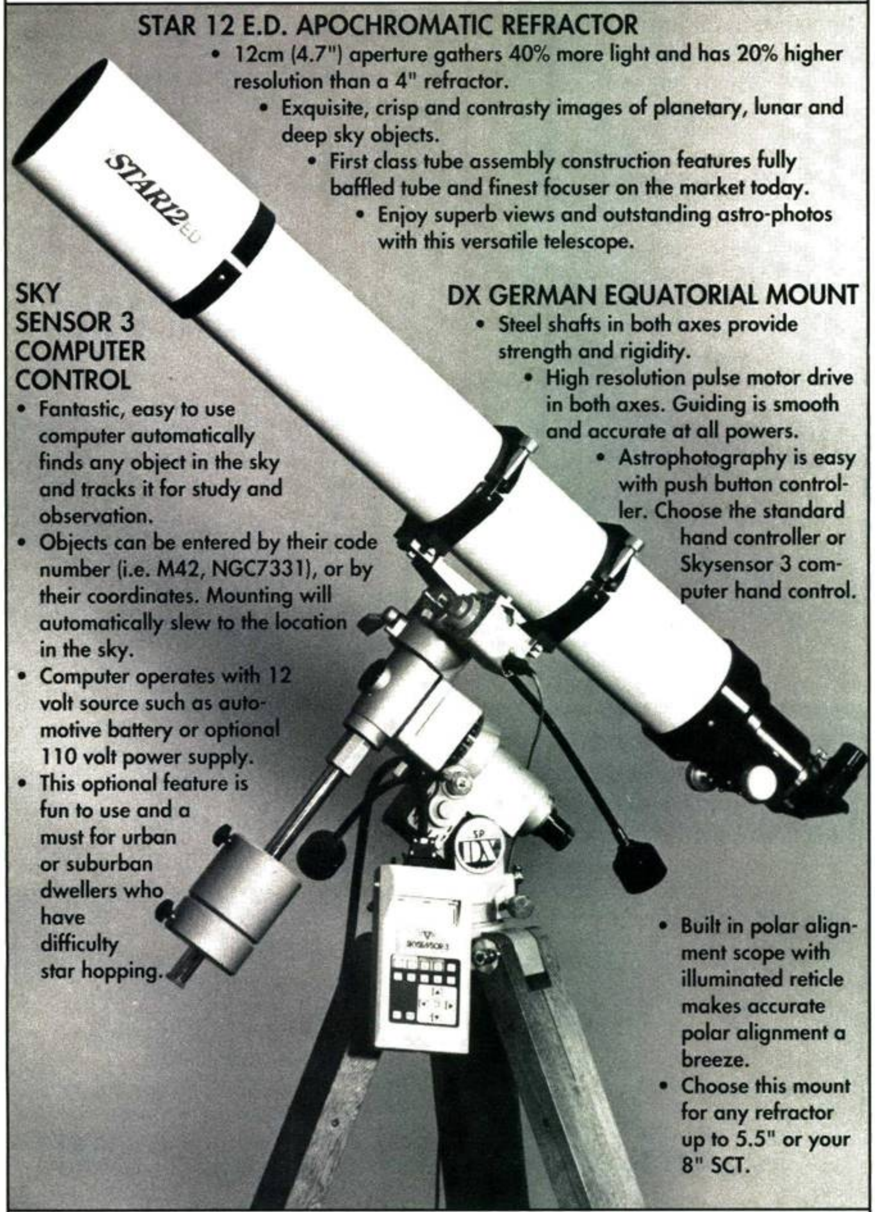

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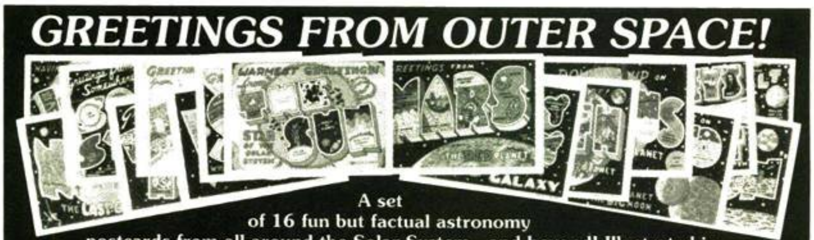

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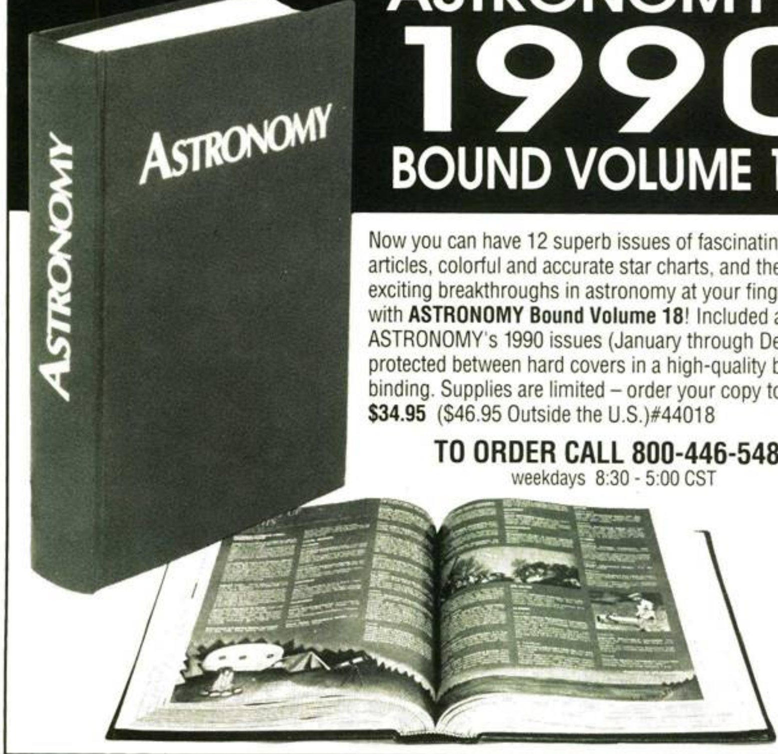

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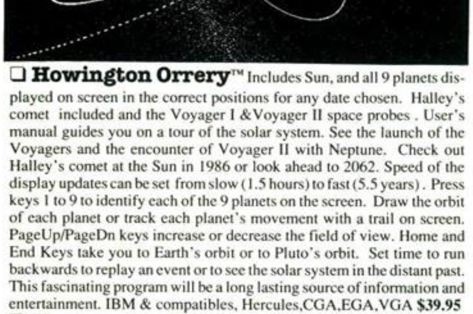

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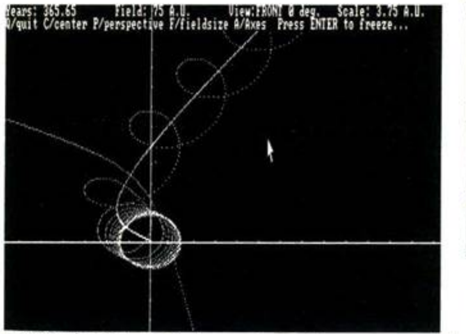

```
Years: 365.65      Field: 175 A.U.      View:FRONT 0 deg.   Scale: 3.75 A.U.
Q/quit C/center P/perspective F/fieldsize A/Axes  Press ENTER to freeze...
```

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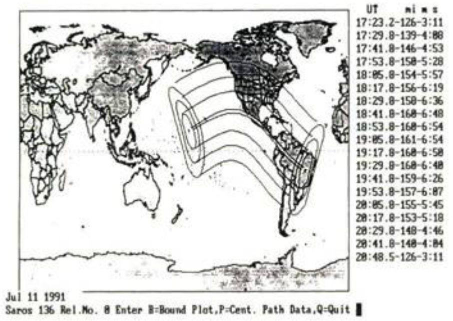

```
UT      mi m s
17:23.2-126-3:11
17:29.0-139-4:00
17:41.0-146-4:53
17:53.0-150-5:20
18:05.0-154-5:57
18:17.0-156-6:19
18:29.0-158-6:36
18:41.0-160-6:48
18:53.0-160-6:54
19:05.0-161-6:54
19:17.0-160-6:50
19:29.0-160-6:40
19:41.0-159-6:26
19:53.0-157-6:07
20:05.0-155-5:45
20:17.0-153-5:18
20:29.0-148-4:46
20:41.0-140-4:04
20:48.5-126-3:11

Jul 11 1991
Saros 136 Rel.No. 0 Enter B=Bound Plot,P=Cent. Path Data,Q=Quit
```

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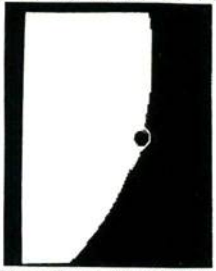
Orion the Hunter



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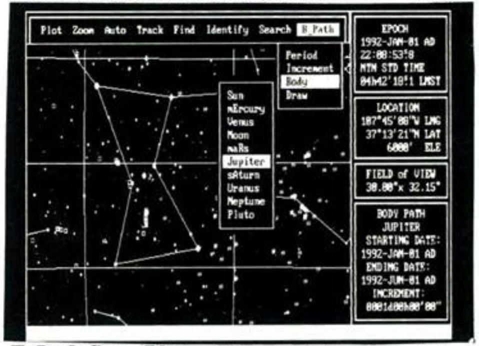

```
EPOCH
1992-JAN-01 AD
22:00:53.8
MTN STD TIME
04h42'18.1 LMST

LOCATION
107°45'00"W LNG
37°13'21"N LAT
6000'  ELE

FIELD of VIEW
30.00°x 32.15°

BODY PATH
JUPITER
STARTING DATE:
1992-JAN-01 AD
ENDING DATE:
1992-JUN-01 AD
INCREMENT:
0001d00h00'00"
```

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Viewpoints

BETWEEN HEAVEN AND EARTH: AN ASTRONOMER'S LIFE

by Brian Skiff as told to Robert Reeves

Brian Skiff enjoys the best of two worlds. During his work day, he works as a professional astronomer at Lowell Observatory, and during play he is an amateur astronomer. No detached professional, Brian is always eager to talk with fellow amateur observers and share their enthusiasm for the sky. Recently, Skiff talked about his evolution into a professional astronomer and about the book, Observing Handbook and Catalogue of Deep-Sky Objects, *a labor of love he co-authored with Chris Luginbuhl.*

Unlike a lot of professional astronomers, I started out as an amateur. In about the eighth grade, a friend showed me M7 through his 2.4-inch refractor. I was hooked. From that time, I decided I was going to be an astronomer one way or another.

I went the standard route of starting with a 2.4-inch alt-az refractor and stepped up to a 6-inch Dynascope, that Newtonian reflector which so many of us have had at one point or another. Finally, I pieced together a 10-inch Newtonian. It was a dues-paying process. Now I have a 6-inch apochromat refractor as well as a 10-inch Ritchey-Chretien Cassegrain reflector.

Nowadays it is fairly unusual for professional astronomers to be avid amateurs as well. From 9:00 to 5:00 I associate with the professional world of astronomy; then after hours I can step back and become an amateur again. But there is not much difference in the way I approach the stuff I do for a living and the stuff I do for fun.

Having done visual observing with telescopes as big as 72 inches in aperture, I find I like both large and small telescopes. There is no perfect telescope to look at everything with. You look at small, faint things with large telescopes and big, bright things with small telescopes.

After finishing college, I edged toward professional astronomy when I worked at the U.S. Geological Survey's Branch of Astrogeology in Flagstaff doing image-processing of Voyager and Viking images. I prepared stuff for airbrush mapping, digital mosaics which became maps, and stereo images. Every now and then something that I did there shows up in print and I think, "Hey, *I* did that!"

Under the Stars at Last

In 1980 I started working at Lowell Observatory, using the Pluto camera — the astrograph used to discover Pluto in 1930 — to take plates for Ted Bowell for his asteroid survey program. That was a quarter-time position, and the work at the Geological Survey filled up the rest. At the end of 1983, I was getting tired of the Geological Survey job. Even though it was planetary science, it was really not what I was interested in, as I tend to think of myself as a stellar astronomer. About that time another Lowell astronomer, Wes Lockwood, mentioned to me casually that he was looking for a competent observer to do photoelectric photometry for a project he was starting. I said, "Me! Me!"

In March 1984 I started doing the observing on the Sun-like stars project, looking for long-term luminosity variations in stars similar to the Sun. This program is still going strong. It is part of an effort to study the solar-stellar connection. In broad terms, the work seeks to find out how the Sun fits in among the stars and whether the things it does are normal, and possibly to surmise what's going to happen next. My photometric survey is now in its seventh year and it is starting to get really interesting.

My work on asteroids has evolved over the years. Ted Bowell's program with the Pluto camera went up to 1987, during which time we generated some-thing like 25,000 positions of about 5,000 asteroids. We targeted objects that had been observed at only two or three apparitions and whose orbits were not certain. Often we would follow them for one or two months so that we could determine a preliminary orbit. If that orbit could be linked up with earlier observations, then these objects could be identified and have proper orbits determined, numbered, and added to the total of known minor planets. During the course of this work, we discovered close to 2,000 new asteroids.

On the one hand, I study asteroids to find out what happened to the solar system a long time ago, while on the other, I am studying Sun-like stars to see what will happen to the solar system in the future. As in other areas of

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astronomy, it is all aimed at understanding bits of the world, trying to find out what is happening in the universe.

Holding History in Your Hand

The Pluto camera is a 13-inch f/5 telescope, so it's the size of a 13-inch Dobsonian, although it is on a sturdy, equatorial mount. It is still pretty much the same machine Clyde Tombaugh used in the 1930s. (See "Clyde and the Clusters," April 1991.) It has the same guidescope with the same spider-web cross-hair eyepiece. Some of the plate holders are still the same. We are still handling today the very same plate holder used to photograph Pluto. The thing I feel when I use the Pluto camera is a strong sense of history, because it was used not only in the Planet X search, but also for the Lowell Proper Motion survey.

The proper motion survey is probably the most significant thing that has been done with that telescope. Proper motion is the movement of a star through space that changes its relative position on the celestial sphere. Tombaugh found a great use for proper motion studies with the Pluto camera. After he found Pluto, Tombaugh kept photographing the sky for Planet X. He covered all the accessible northern sky by the beginning of World War II. This collection of plates is the earliest deep, homogeneous sky survey in existence.

In the mid-1950s, Henry Giclas, with the assistance of Norm Thomas and Robert Burnham, Jr. (author of *Burnham's Celestial Handbook*), started doing their own proper-motion survey. They retook the 14- by 17-inch plates on the same field centers as the original Tombaugh survey. Instead of blinking a pair of plates that were taken an hour apart, to seek motion at asteroidal distances they blinked pairs that were taken roughly 30 years apart looking for motion at stellar distances. They found about 7,500 new large proper-motion stars.

The third notable thing that the Pluto camera has been used for is the asteroid survey that we did in the 1980s. It's a special feeling to be adding to it like a latter-day Clyde Tombaugh. The Pluto camera is still valuable, even though it is old. Last year, for instance, I obtained the first astrometry — accurate positions — both on Comet Aarseth-Brewington and Comet Skorchenko-George. Brian Marsden, director of the Harvard-Smithsonian's Central Bureau for Astronomical Telegrams, would send me an e-mail message saying, "There is a new comet roughly here; could you get some positions for us?" I

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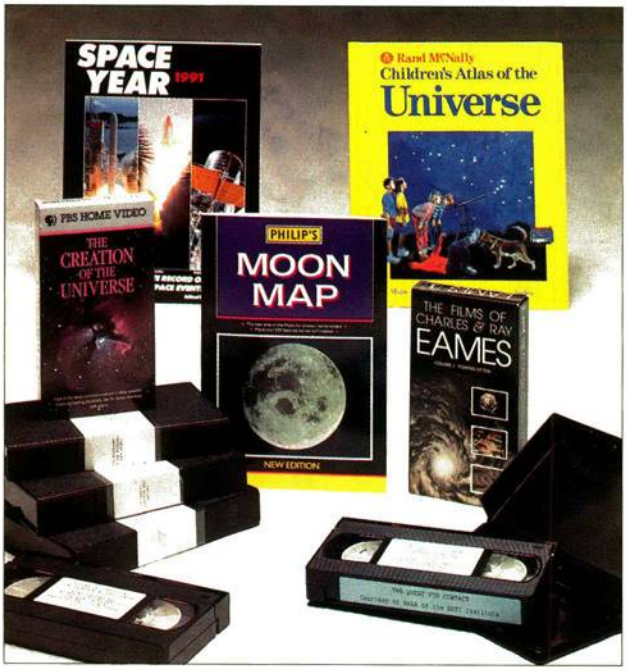
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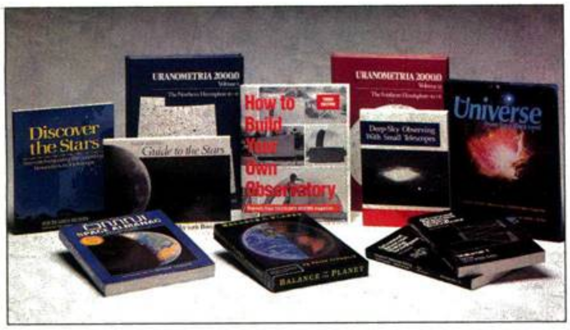

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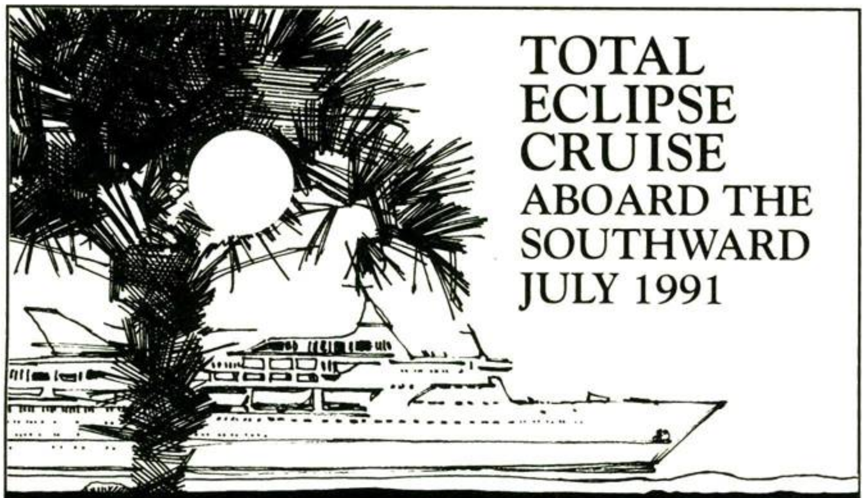

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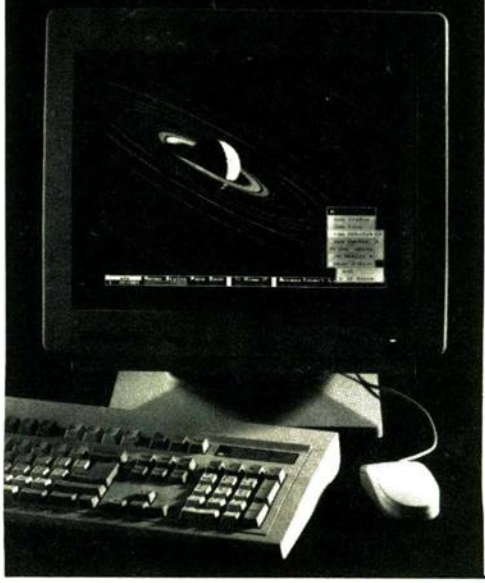

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could go out the same night, get plates, develop them, measure them myself, and send them in. The camera is still useful for this sort of "instant" astronomy.

Into the Publishing Realm

The book I co-authored, the *Observing Handbook and Catalogue of Deep-Sky Objects,* was strictly an amateur project, not professional. The book started when a friend of mine, Hank Messick, and I were sitting around on a sweltering August afternoon in Florida, having observed a couple of hundred deep-sky objects with several different telescopes the previous few months. We were wondering why there was not a book that had observations made with different apertures we could compare ours with. Hank's father, who was an author, was standing by and said, "Well, since you guys are the experts, why don't *you* do it?"

When Hank, Chris Luginbuhl, and I were in college in Flagstaff, we decided to press forward on the project. We actually finished a draft in 1978, but because of various complications with the original publisher, it was never printed. There was an ad in *Sky and Telescope* in 1982 saying Cambridge University Press was looking for books to publish in the amateur astronomy market.

Hank had lost interest by that time, so Chris and I sent in some samples extracted from the original manuscript and got a contract from Cambridge. We did a lot more observing up until 1982 and then spent over two years writing the book, preparing the illustrations, and so forth. Now it is out! So it has taken more than 15 years to see the book to fruition. In the meantime, both Chris and I have become professional astronomers.

Our observing list consisted of objects plotted in the old Skalnate Pleso *Atlas of the Heavens.* Remember, there was no Tirion *Sky Atlas 2000.0,* no *Uranometria,* only the Skalnate Pleso and the large scale Becvar atlases, on which we plotted thousands of galaxies, clusters, and nebulae. We tried to find up-to-date data about each object, particularly basic parameters on the "observables" that affect what you see through the telescope: the size, total brightness, the magnitudes of cluster stars, and so on. Chris and I tried to tie the necessarily qualitative visual observations to hard numbers like magnitudes and surface brightnesses and to the *Palomar Observatory Sky Survey.* The aim was to provide a *firm* footing to compare our observations against and to present the combination for our readers' own use.

We thought that by having the aesthetic side of the visual observing tied to the technical data — something you can actually measure rather than some-thing you just feel when you look through a telescope — you get a better understanding of what you are seeing and a more profound aesthetic experience as a result.

The Social Astronomer

The observing I do at Lowell, both with the comet and asteroid astrometry and the Sun-like stars photometry, is part of two observing-intensive, long-term projects. In both cases, I am (or was) the main user of two instruments. I have these two telescopes available almost every night, so if I want to attend a symphony or go on a date or just stay home, I can do that. It's not like an ordinary observing project where you go to an observatory and have an intense period of observing and data-gathering and then go home and sit in the corner of your office for nine months to figure out what you've got.

Only a third of the nights are photometric in Flagstaff, that is, cloud-free from dusk to dawn. Only on really good photometric nights can I do photometry on the Sun-like stars because the size of the variations we seek are extremely small. If I decide to have someone over for dinner or go out next Wednesday, there is a 2-out-of-3 chance it will be cloudy, and I will be able to go. Even so, the typical social engagement does not last all night. When it is finished, I can go to work.

I am not the "monk in the dome" night *after night* — most nights are cloudy! I used to be a grind in the early days of the photometry work, but I have mellowed out. I sometimes feel guilty about it, but you have to be nice to yourself! You have to remember that you are a human being.

Getting to Know the Sky

I sometimes hang out in the Lowell visitor's center just to talk to people and spread a little good will for the observatory. Beginners often ask, "I want to buy a telescope — what should I get?" The first thing I tell them is to get a pair of binoculars, and a book like *Bright Star Atlas 2000* or one of the piles of introductory books. Then they almost invariably say, "But I want a telescope!" I reply that if they really need to, they can get a scope like an Edmund Astroscan, one that is fixed at 20 power and has a nice 3° field of view, *and* get a pair of binoculars!

People often have trouble with the change in scale from the naked-eye view to the telescopic view of the sky. What you need to do is work up step-by-step. A pair of binoculars and the naked eye is the way to go. You can spend a lot of time learning the constellations, learning the names of the bright stars, learning where the deep-sky objects are, and becoming friends with the stars.

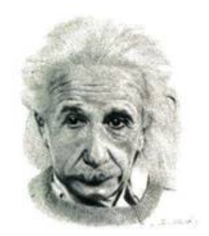
You should develop a social relationship with the sky before you dive in and overwhelm yourself. A lot of professionals have no friendly relationship with the sky, so they have to rely on setting circles or coordinate readouts. If the thing fails, they cannot just point it to the general part of the sky and find the thing themselves. They have *no idea* where it is.

I think of the stars as friends of mine since I observe them hundreds of times, particularly the Sun-like stars in my photometry program. When 11 Leonis Minoris comes up in the early-winter morning sky, I make my first observation of the season. I look through the telescope and literally say out loud, "Hi! What are you going to do this year?"

People often accuse me of not having as much fun observing as they do because I am into all this catalogue data! In fact, I would argue it is just the opposite. When I get to the telescope and review what I am going to write notes about, I look as carefully as I can to get verifiable numbers, such as the orientation of a galaxy or the number of stars visible in an open cluster. I have a mental list of things to check for in each class of object.

Taking notes that are quantitative and as detailed as possible forces you to look more carefully at an object. Since most objects observable in any given telescope are very faint, you gain a lot of visual acuity on the difficult things; when you go to M51, you see a lot more than you would if you were just observing casually. After looking at fifty 13th-magnitude galaxies in Canes Venatici, you go to M51 and you realize what an extraordinary object it is, unique in the entire sky! You see even with a 10-incher: there are the spiral arms. That is when all that hard training pays off, when that aesthetic, spiritual feeling strikes you, and you say to your self, "Wow, this is really incredible!"

If you do not do this training, and just tick off a number on a list, then you are not going to develop the skills you need to get as much as you can out of your telescope. You are not going to have as much fun; you are not going to get the real payoff. ☐



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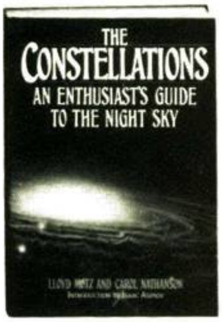
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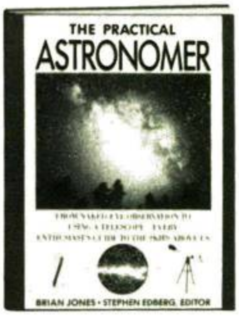
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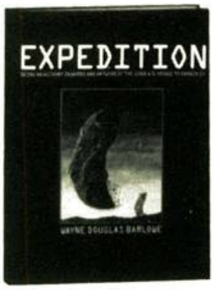
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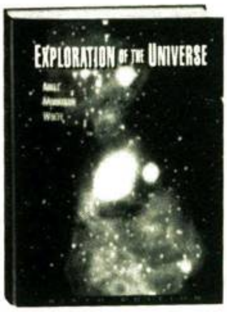
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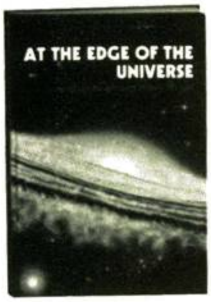
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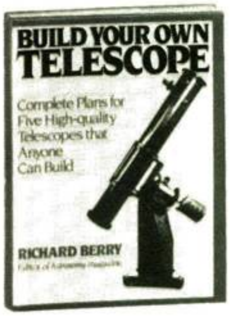
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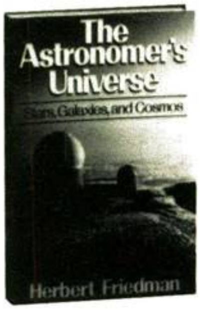
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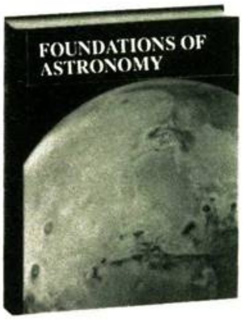
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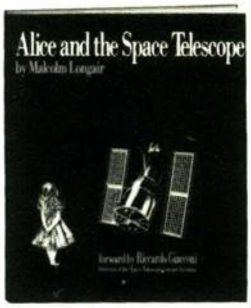
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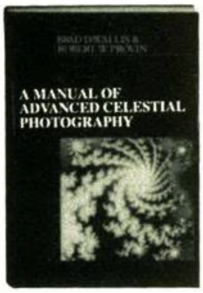
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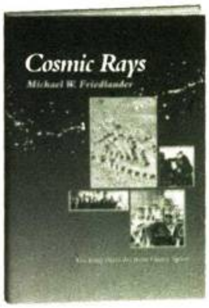
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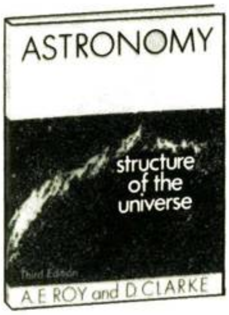
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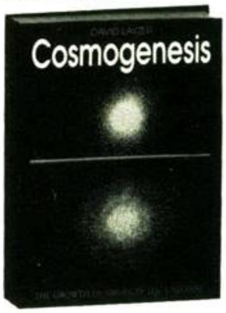
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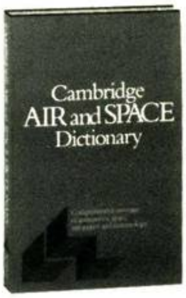
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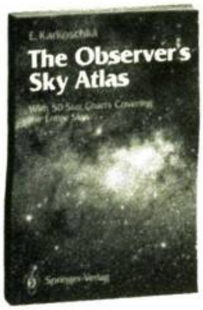
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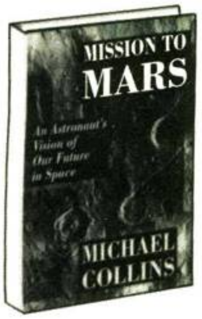
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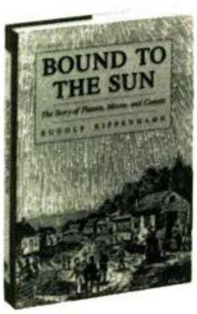
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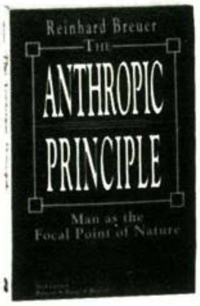
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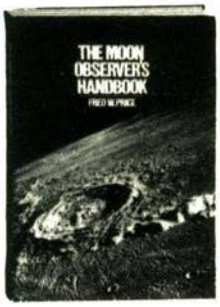
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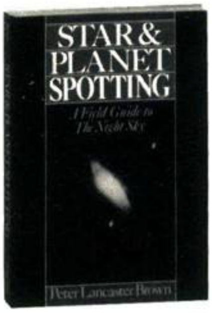
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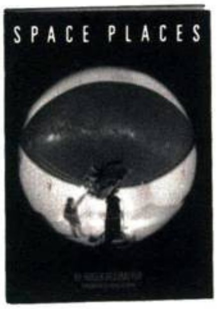
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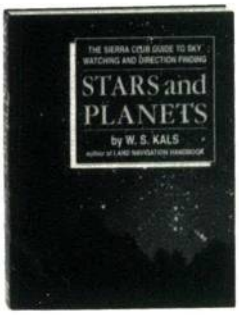
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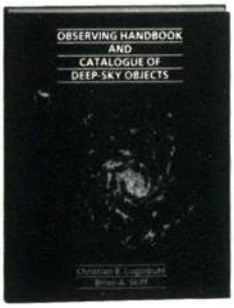
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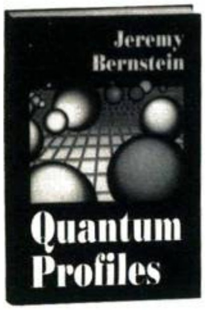
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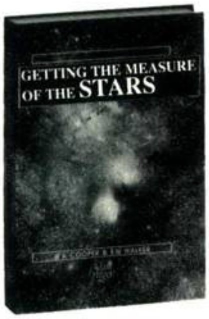
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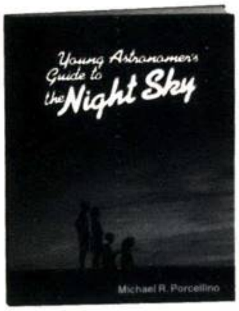
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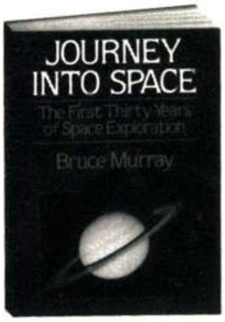
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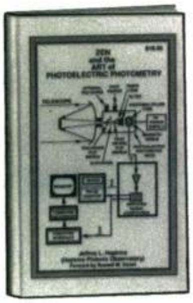
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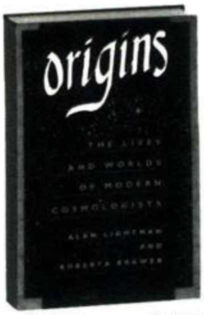
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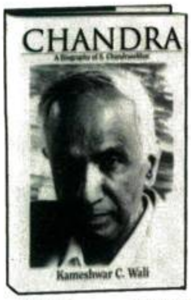
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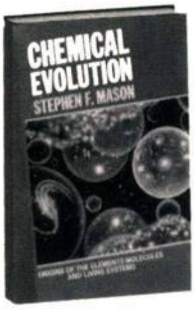
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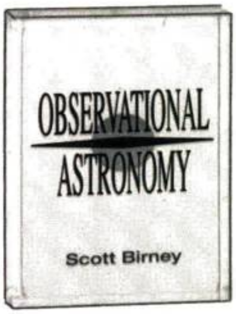
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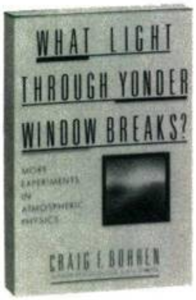
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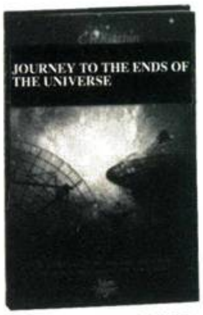
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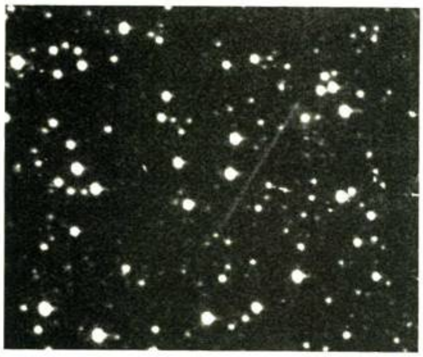
ASTEROID NARROWLY MISSES EARTH

On January 17, 1991, a tiny asteroid whizzed past Earth at an uncomfortably close distance — so close, in fact, that it passed within only half of the distance between Earth and the Moon. Designated 1991 BA, the asteroid was the smallest, closest asteroid ever observed.

"We've found 10 Earth-approaching asteroids by using the 36-inch telescope at Kitt Peak, but this asteroid is the closest one anybody has seen," says David Rabinowitz, a member of the Spacewatch Team at the University of Arizona. The tiny asteroid left a faint trail on the computer screen that scans for asteroids coming within view of the telescope's liquid nitrogen cooled camera. "Asteroid 1991 BA had a magnitude of 17 and is approximately 5 to 10 meters in diameter," according to Rabinowitz.



A FAINT TRACK IN THE NIGHT, light from asteroid 1991 BA streaked across a plate in this Spacewatch image. On January 18, 1991, the asteroid passed within just 106,000 miles of Earth. Photo courtesy James Scotti, University of Arizona.

The discovery of 1991 BA caught Rabinowitz and the Spacewatch team by surprise. It came within 0.0011 astronomical unit, or 106,000 miles, of Earth. The Moon lies at about twice that distance from Earth.

"The intruder was not automatically picked up by the computer," relates James Scotti, an astronomer at the University of Arizona. Normally, the computer would alert astronomers to the discovery of an asteroid, but this time Rabinowitz himself spotted 1991 BA on the computer screen, Scotti asserts.

Now well past Earth, 1991 BA is outbound from the Sun. Its orbit is estimated to extend from the orbit of Venus to beyond the asteroid belt. The object travels at a speed of almost 12 miles per second and makes its way around the Sun once every three to four years.

Prior to the discovery of 1991 BA, the closest sighting of an Earth-approaching asteroid came in March 1989. That asteroid was about 100 meters in diameter and passed at a distance 10 times that of the Moon. — *Joseph Baneth Allen*

CHIRON: CYANOGEN GAS EMISSION DETECTED

The unusual object 2060 Chiron has developed a gas coma of cyanogen, according to a report published in the February 15, 1991 issue of *Science* by Schelte J. Bus, David Schleicher, and Edward Bowell of Lowell Observatory, and Michael A'Hearn of the University of Maryland.

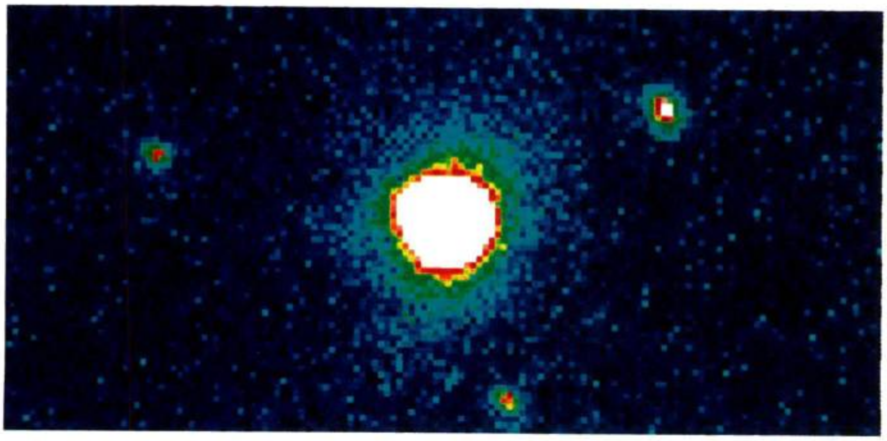
At the time of the observations, Chiron was 11.3 astronomical units from the Sun and slowly approaching perihelion, which it will reach in 1996. The coma extended on both sides at least 7 seconds of arc, which at Chiron's distance translates to some 50,000 kilometers.

Chiron, which orbits between Saturn and Uranus, was classed as an asteroid when it was discovered in 1977 and assigned minor planet number 2060. But in mid-1989, astronomers discovered that it had developed a faint coma of dust and so more properly ought to be classed as a comet. The new finding emphasizes Chiron's cometary nature.

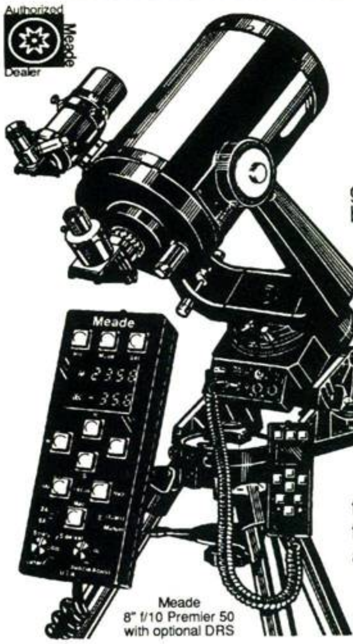
Cyanogen (CN) is commonly found in the spectra of the nuclei and ionized gas tails of comets, but it has never before been detected at such a great distance from the Sun. Cyanogen results from the breakup of a parent molecule such as hydrogen cyanide (HCN) or from more complex organic polymer grains. In the case of Chiron, the parent is as yet unidentified but the researchers point to HCN as the most likely candidate and think that it was expelled under the growing warmth of the Sun by outbursts of carbon dioxide ice. These outbursts, they believe, erupted from isolated pockets of ice on Chiron and point to a heterogeneous composition for the object.

Another Chiron study was published in the same issue of *Science* by Mark Sykes of Steward Observatory (University of Arizona) and Russell Walker of Jamieson Science and Engineering.

They used observations made from the ground and by IRAS, the Infrared Astronomical Satellite, to determine an upper limit to Chiron's size, which is too small to be measured directly. Using the ratio between Chiron's infrared and visual brightnesses, they calculated that Chiron could be as large as 372 kilometers in diameter, about twice the size of previous estimates. (Even the old, smaller estimates for Chiron's size were larger than any other comet nucleus known.) As Chiron draws nearer the Sun it promises more surprises in the years to come.



CHIRON SHOWS A DUST COMA (light blue halo) around its nucleus in this false-color image taken in red light on January 29, 1990, by Jane Luu and David Jewitt of the University of Hawaii. By coincidence, this image was taken roughly 24 hours before Bus and his coworkers made the first detection of cyanogen in a gaseous coma around Chiron (see story).



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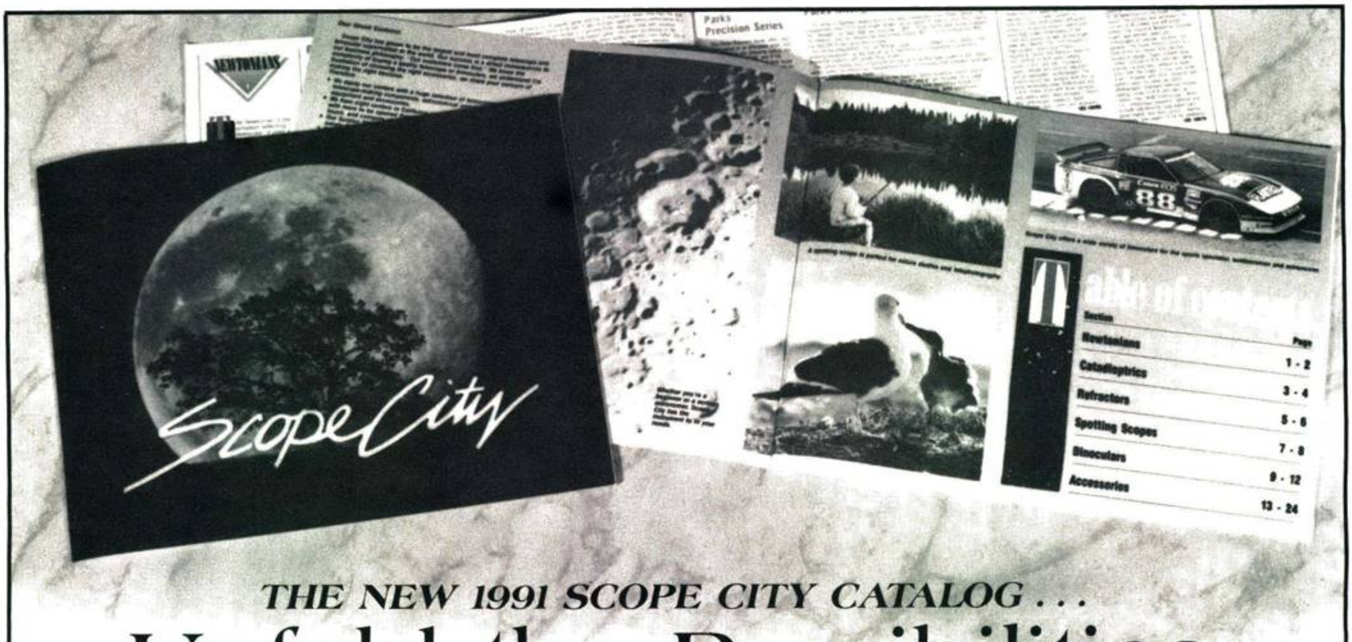

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THE CHAOTIC SUN

Chaos is a hot topic in astronomy and it has become even hotter — as hot as sunspots in fact. Astronomers have long known that sunspots rise and fall in number through an 11-year cycle. However, sunspot watchers who have also noted variations in sunspot numbers over longer periods have wondered if these represent other predictable cycles. After analyzing the monthly mean sunspot numbers from January 1749 to May 1990, a team of University of Colorado astronomers found that while sunspots have a cyclical behavior in the short term — the 11-year cycle — their long term trend is chaotic. So conclude the team of Michael Mundt, W. Bruce Maguire, and Robert Chase of the Colorado Center for Astrodynamics Research.

Prior to the application of chaos theory to the Sun, astronomers had assumed sunspot activity to be so complex it would require thousands of mathematical equations to model it accurately. But the equations governing chaos theory are relatively simple. For example, the research team's sunspot analysis indicates that the Sun may be driven by a simple solar-dynamo which could be modeled by only three mathematical equations. Using the mathematics of chaos theory, solar astronomers may be able to better analyze the bahavior of sunspots and the underlying activity of the Sun.

Chaos theory also predicts long spot-free periods of solar history like the Maunder Minimum. During this period between 1645 and 1715, sunspots so rarely appeared that when they did they were announced as new discoveries. If the Sun is behaving like a chaotic system, long periods of sunspot absences would be expected, as well as extended periods of heightened sunspot activity. — *Jeffrey Risner*

HOW FAR TO THE LMC?

A highly detailed image of supernova 1987A taken by the Hubble Space Telescope's Faint Object Camera has helped astronomers calculate a new and more accurate distance to the Large Magellanic Cloud. This improved value, in turn, has exciting implications for cosmology because the distance to the LMC is a cornerstone for determining the size and age of the universe.

The new observations give a distance of 169,000 light-years to supernova 1987A and is accurate to within 5 percent. This also gives the distance to the Large Magellanic Cloud — the larger of the Milky Way's two satellite galaxies — because 1987A occurred in the LMC and all objects in that galaxy are at the same approximate distance. Previous estimates of the LMC's distance ranged between 143,000 and 179,000 light-years, a spread of 25 percent.

"This is an achievement of great importance because the distance to the Large Magellanic Cloud is an essential step to the calibration of the cosmological distance scale," said Nino Panagia of the European Space Agency, a member of the international team of astronomers who established the new distance. "Being able to determine this distance with an accuracy of 5 percent means that after a few more comparable steps, we will be able to estimate the Hubble constant [which gives the distance scale of the universe] to an accuracy of 10 to 15 percent and thus the age of the universe with that high an accuracy as well."

The new distance is based on observations of a luminous ring of material surrounding supernova 1987A. The ring

Amateur News

ASTRONOMY PARTICIPATES IN OPERATION DESERT STORM

ASTRONOMY magazine is one of 35 magazines being shipped to U. S. and allied forces serving in the Persian Gulf region in Operation Desert Storm. Operation Desert News, a non-profit corporation sponsored by the R. J. Reynolds Co., began distributing the titles to soldiers and sailors in the gulf last January. Besides ASTRONOMY, armed forces personnel can sample *FineScale Modeler, Model Railroader, Armed Forces Journal, The Nation, Americana,* and *Modern Drummer.*

"We were happy to provide ASTRONOMY," said the magazine's editor Richard Berry. "Our mission is to spread awareness of astronomy, and the fact that Operation Desert News requested our title shows that astronomy can be enjoyed anywhere, by anyone, without special equipment. We're happy if we can provide even a few moments' relief to the men and women serving in Operation Desert Storm."

AN ASTRONOMY WEEK IN WYOMING

If you're looking for ideas for an astronomical vacation this summer, you may wish to consider a trip to scenic Laramie, Wyoming. From June 22 to 28, the Astronomical Society of the Pacific will be holding its 103rd Annual Meeting at the University of Wyoming. Co-sponsored by ASTRONOMY Magazine/Kalmbach Publishing Co., the Laramie meeting is expected to attract a unique mix of amateur astronomers, professional researchers, educators, and interested members of the public.

The program for the 7-day meeting includes a seminar on "Astronomy in the 1990s," featuring reports from members of the National Academy of Sciences committee that has recommended future directions for astronomy in the United States. The schedule will also include "Universe '91," a program of popular lectures on new developments in astronomy by noted researchers, as well as talks and demonstrations about trends in amateur astronomy. Topics will cover Cosmic Catastrophes, the Hubble Space Telescope, Light Pollution, Debunking Astrology, the Invisible Universe, Astronomical Photography, and much more. "The Universe in the Classroom" will be a credit workshop on teaching astronomy in grades 3 to 12. There will also be a kickoff Saturday evening star party on June 22. According to the Society's spokesman, Andrew Fraknoi, "the Wyoming area offers some of the most spectacular scenery in the U.S. and many participants will be using the meeting as a starting point for a family or hiking vacation."

The A.S.P. has arranged inexpensive dormitory and hotel accommodations, as well as discounts on air travel and car rentals. For more information and a compete registration packet, write to: The Astronomical Society of the Pacific, Meeting Information Dept., 390 Ashton Avenue, San Francisco, CA 94112, or call (415) 337-1100.

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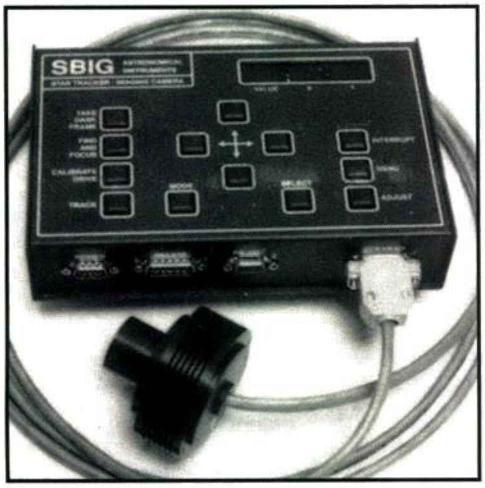

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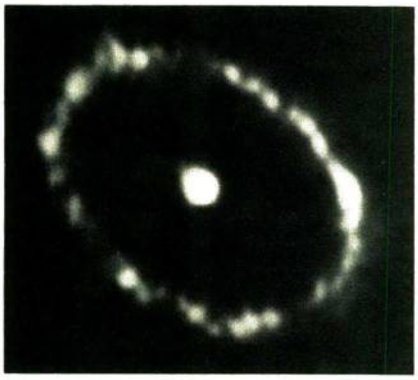
is composed of material ejected by the supernova's progenitor star in the final two stages of its evolution. In the first stage, which began more than half a million years ago, the star was a red supergiant emitting a gentle wind of particles at about 10 kilometers per second. In the second stage, which began only about 5,000 years ago, the star evolved back into a blue supergiant and its stellar wind sped up to some 600 kilometers per second. The faster material then swept up and compressed the slower material along an equatorial belt, producing the ring-like structure. The ring glows today from the high-energy radiation released in the 1987 explosion.

The researchers measured the ring's angular diameter directly from the high-resolution image made by the Faint Object Camera. That gave a diameter of 1.66 arcseconds, which is equivalent to the apparent separation of a car's headlights viewed from 100 miles away. But to find the distance to the object, the astronomers needed to know the true physical diameter of the ring.

That information came from the International Ultraviolet Explorer satellite, which has been measuring the brightness of the supernova since the explosion. Because the ring is tilted 43° to our line of sight, the light from it did not all reach us at the same time. After analyzing the IUE data, the astronomers found that light from the near edge of the ring reached Earth 80 days after the explosion and light from the far edge reached us 420 days after the explosion. The researchers could then calculate the true physical diameter of the ring from the time difference and the ring's tilt. The result was 1.37 light-years.

With precise values for the both the angular and physical diameters, the astronomers calculated the true distance to the supernova and thus the LMC — 169,000 light-years. During the coming years, this new measurement will serve as a foundation for achieving more accurate distances throughout the cosmos.



THIS LUMINOUS RING surrounding supernova 1987A may hold the key to determining extragalactic distances. The gaseous ring was photographed in unprecedented detail by HST's Faint Object Camera. NASA/ESA photo.

Space News

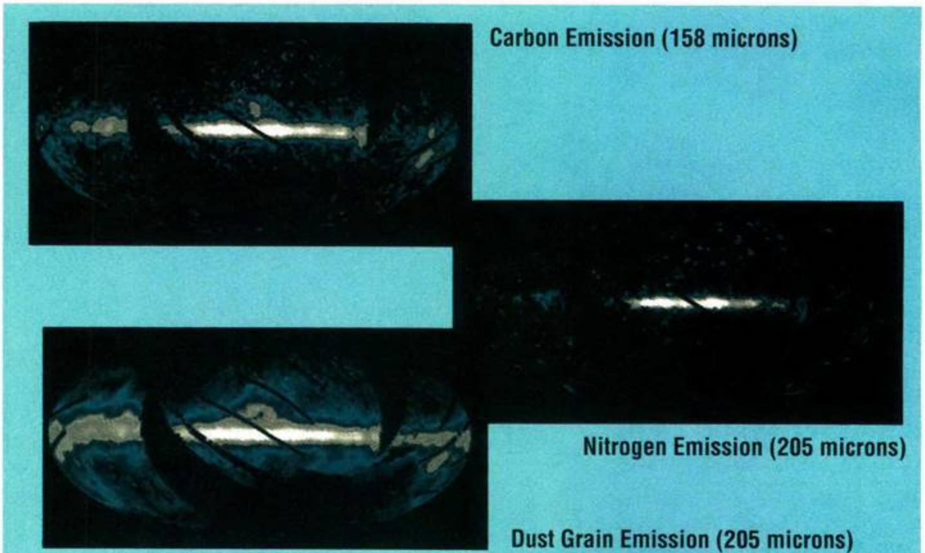
A WETTER VENUS?

New Earth-based measurements of the amount of the element deuterium at Venus confirm earlier findings by the Pioneer Venus spacecraft and indicate that Venus is about 120 times richer in the element than Earth. This in turn suggests that Venus had much more water in the past than it does today.

The earlier Pioneer data, taken by instruments in Venus orbit and by probes that landed, had been in question since they apparently conflicted with data from the International Ultraviolet Explorer satellite. The IUE data, however, depended heavily on possibly erroneous models of the Venusian atmosphere for their interpretation.

To resolve the question, French astronomer Catherine de Bergh headed a multinational team using the Canada-France-Hawaii telescope to take new measurements. Reaching the same conclusions as Pioneer did, the team reported its findings in the February 1, 1991 issue of *Nature*.

Despite the new results, the question of where the water came from is still unsolved. The main choices are that Venus formed wet and once had oceans, that impacting comets intermittently brought water to the essentially dry planet, or that some combination of the two processes occurred. At present, most planetary scientists lean toward the "vanished oceans" explanation, but the question is still an open one.


Carbon Emission (158 microns)
Nitrogen Emission (205 microns)
Dust Grain Emission (205 microns)

NEW MAPS OF THE MILKY WAY prove that carbon and nitrogen atoms, two of the building blocks of life, are widespread in the thin gas that fills the space between the stars. Compiled over 5 months, the data for the new maps came from the Far Infrared Absolute Spectrometer on NASA's Cosmic Background Explorer satellite (COBE). The top map, made at a wavelength of 158 microns, charts the distribution of interstellar carbon in our Galaxy. The middle map, made at 205 microns, shows the location of ionized nitrogen, while the bottom map indicates emission from grains of interstellar dust. The COBE maps show our Galaxy to be a typical spiral and should help astronomers discover more about the role interstellar material plays in the workings of the Milky Way. Photos courtesy the COBE Science Working Group and Goddard Space Flight Center, NASA.

Meetings & Events

For a complete listing of summer star parties and amateur events, see the special pull-out insert, "Your 1991 Astronomy Activity Guide," in the center of this issue.

April 20
Astronomy Day. Contact: Gary Tomlinson, Astronomy Day Coordinator, c/o Chaffee Planetarium, 54 Jefferson SE, Grand Rapids, MI 49503. Phone: (616) 456-3987.

April 20
Astronomy Day celebration, Hoffman Estates, Illinois. Sponsored by the Northwest Suburban Astronomers. Contact: Michael D. Mangan, 208 Islington, Schaumburg, IL 60193. Phone: (708) 980-0080.

April 20
Astronomy Day celebration, Charles Hayden Planetarium, Boston, Massachusetts. Contact: Noreen A. Grice, Education Coordinator, Charles Hayden Planetarium, Museum of Science, Boston, MA 02114. Phone: (617) 589-0270.

April 20
Astronomy Day 1991, National Air and Space Museum, Washington, D.C. Contact: Cheryl Bauer, Room 3356B, National Air and Space Museum, 6th & Independence Avenue, S.W., Washington, DC 20560. Phone: (202) 357-1529.

April 20
Astronomy Day and 60th Anniversary Celebration, Madison, Wisconsin. Sponsored by the Madison Astronomical Society. Contact: Bob Manske, 404 Prospect Street, Waunakee, WI 53597, (608) 849-5287; or Dave Weier, 205 Cameo Lane, Madison, WI 53714, (608) 241-1444.

April 23-26
28th Space Congress, Cocoa Beach, Florida. Sponsored by the Canaveral Council of Technical Societies. Contact: Canaveral Council of Technical Societies, P.O. Box 321333, Cocoa Beach, FL 32932.

May 2-4
Middle Atlantic Planetarium Society Conference, Franklin Institute Science Museum, Philadelphia, Pennsylvania. Phone: (215) 448-1293.

May 10-11
AstroFestival '91, Roberson-Kopernik Observatory, Vestal Center, New York. Sponsored by the Kopernik Astronomical Society. Contact: Roberson-Kopernik Observatory, Underwood Road, Vestal Center, NY 13850. Phone: (607) 772-0660.

May 18
Astroganza '91, Abrams Planetarium, East Lansing, Michigan. Sponsored by the Capital Area Astronomy Club. Contact: Kurt Melvin, Abrams Planetarium, Michigan State University, East Lansing, MI 48824. Phone: (517) 546-7089 (evenings).

May 22-27
10th Annual International Space Development Conference, San Antonio, Texas. Sponsored by the National Space Society, Kelly Air Force Base, and the San Antonio Space Society. Contact: Carol Luckhardt Redfield, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78228. Phone: (512) 522-3823.

June 7-14
Beginning Astronomy Camp for Teens, Tucson, Arizona. Contact: Joan L. Morrill, Arizona Alumni Association, 1111 North Cherry, Tucson, AZ 85721. Phone: (800) 232-8278 (outside Arizona), or (602) 621-5233.

June 14-15
6th Annual Sedona-Verde Valley Astrophotography Festival, two hours from Phoenix, Arizona. Sponsored by Rainbow's American Dream. Contact: Russell Nidey, 1101 Zalesky Road, Cottonwood, AZ 86326. Phone: (602) 634-7332.

June 17-24
Advanced Astronomy Camp for Teens, Tucson, Arizona. Contact: Joan L. Morrill (see June 7-14 entry).

June 22-23
The Universe in the Classroom, University of Wyoming, Laramie, Wyoming. Contact: Astronomical Society of the Pacific, Teachers' Workshop Information, 390 Ashton Avenue, San Francisco, CA 94112. □

Please submit announcements at least four months before the date of the meeting or event.

When you write to organizations listed in Meetings and Events, include a self-addressed, legal-sized envelope with your request for information.

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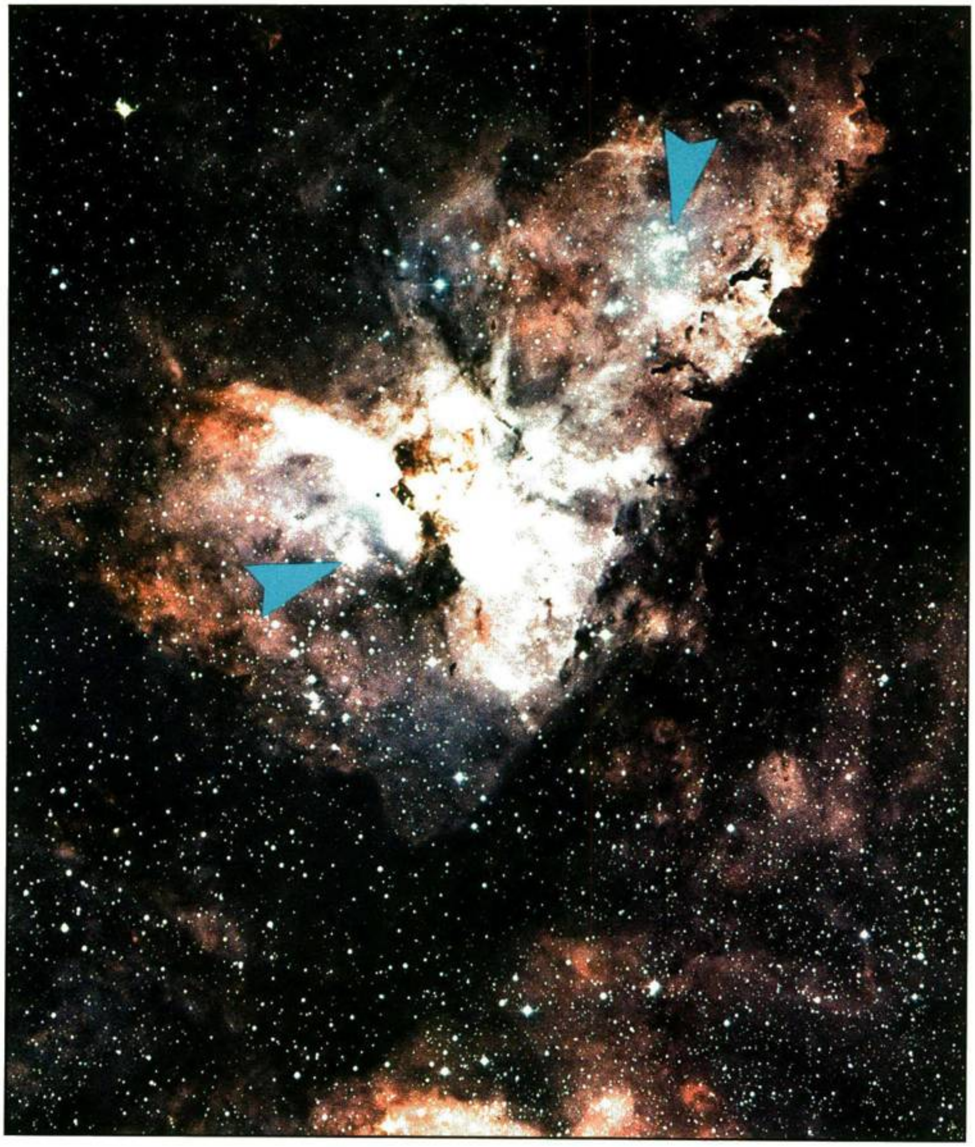
The Brightest Stars in the Universe

Doomed to cataclysmic ends, the most luminous stars in the Galaxy outshine the Sun many millionfold.

by James B. Kaler

LARGE, EXTREMELY HOT, AND SHINING FIERCELY, blue supergiant stars are the Galaxy's — and probably the universe's — most luminous. These wastrels burn their nuclear fuel at such prodigious rates that each can live only a few million years. Painting by Robert Eggleton.



A STELLAR POWERHOUSE, the luminous blue variable Eta Carinae (lower arrow) lies cocooned in dusty gas, while similarly shrouded HD 93129A (upper arrow) is the most luminous star known. Photo courtesy Anglo-Australian Telescope Board.

Some moonless night this summer, look up toward Cygnus, the celestial Swan caught in its silent flight south through the Milky Way. The tail of the Swan is marked by Deneb, the white 1st-magnitude star that also marks the northeast apex of the Summer Triangle. Deneb shines a little more dimly than the other two in the Triangle, Altair in Aquila and Vega in Lyra. But which star is really the most luminous?

Vega and Altair are truly bright. Both are spectral type A stars on the main sequence and have absolute magnitudes of 0.7 and 2.3, respectively. (Absolute magnitude is how bright a star would appear from a standard distance of 32.6 light-years.) Measured the same way, the Sun would reach a mere 4.8 magnitude, about as bright as the faintest star in the Little Dipper and some 44 times dimmer than Vega.

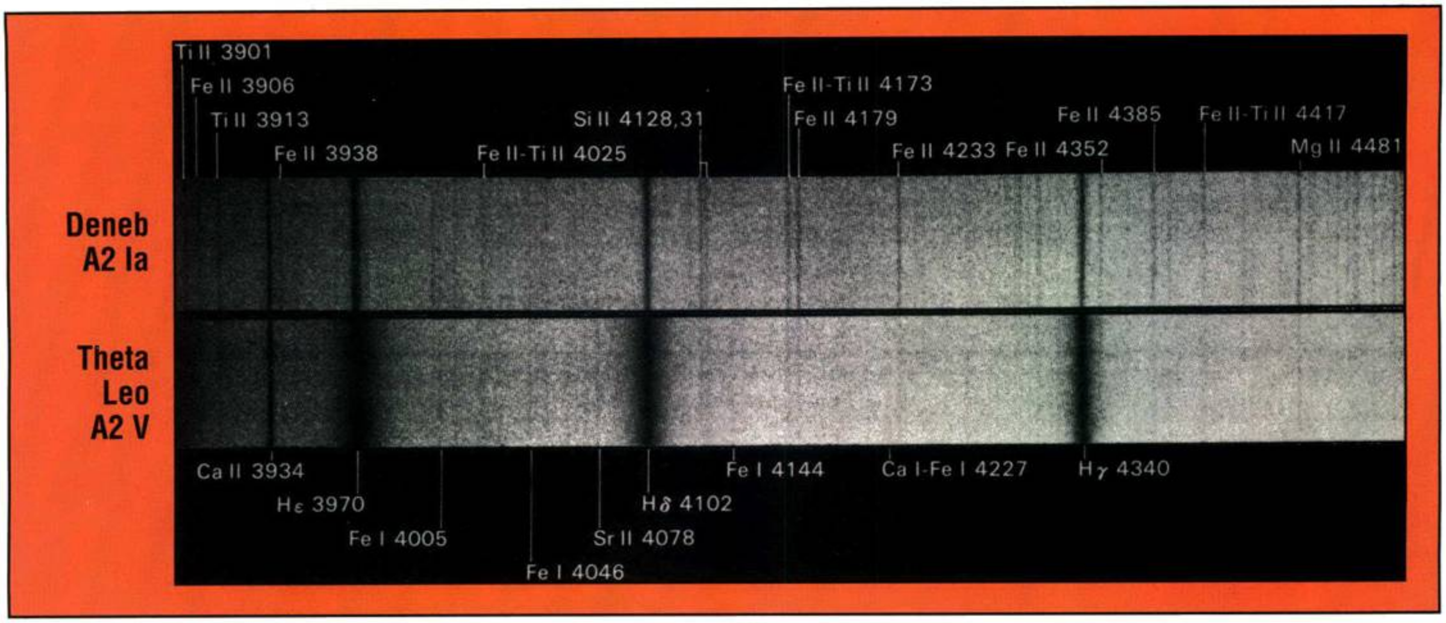
But as bright as Altair and Vega are, they are dim candles compared to Deneb, deceptively the least impressive of the three. In fact, Deneb is a supergiant star, the most luminous known in spectral class A. It seems relatively dim only because it lies 1,500 light-years away, 60 times farther than Vega. Deneb's absolute magnitude is an astonishing –8.4 and if this star were placed alongside Vega, it would shine at magnitude –9. It would be easily visible in full daylight and would cast distinct shadows at night.

With Deneb, we leave behind the stars of the ordinary main sequence and enter a strange realm of enormous and massive objects that shine with immense power. Fueled by huge nuclear engines, these supergiant stars transform themselves quickly from one odd kind to another as their nuclear furnaces greedily consume fuel. As the table on page 37 shows, from our perspective on Earth, the brightest supergiant is Rigel, the western knee of Orion. Even more intrinsically luminous than Rigel is Zeta^1 Scorpii, a hot B-type star that marks the start of the curve of the Scorpion's tail. And some dark night try to find Rho Cassiopeiae, a full magnitude more luminous than Deneb.

Toward the top of the table stand two strange and famous individuals, P Cygni and Eta Carinae. P Cygni is the prototype of a class of stars whose odd-looking spectra proclaim that star-stuff is streaming away from them in a vigorous "wind." Eta Carinae (left) is more bizarre still, because we cannot even see the star itself; it is hidden in a dust shroud of its own making, and we can only guess from the properties of the cloud what kind of stellar powerhouse lies within.

Let's now turn to a pair of stars that are poorly known to the astronomical public and carry only catalogue names. Third on the list is Cygnus OB2 #12, a drab name for an unusual body. With an absolute magnitude of –9.9, it is the most luminous star (at visual wavelengths) yet discovered. This type B supergiant, located near Gamma Cygni, lies only 3.5 times farther than Deneb, yet has an apparent magnitude of 11.5 — dim enough to require a modest telescope if you want to see it. So why is it faint? The answer is interstellar dust, which dims the star by 10 magnitudes, a factor of 10,000. With no dust in the way, Cygnus would have *two* 1st-magnitude stars, Cyg OB2 #12 would probably bear some well-known common name, and Cygnus might even be called something else.

At the top of the list, we see HD 93129A, a star that coincidentally appears in the photo with Eta Carinae. Its absolute visual magnitude of –7 is deceptively low because the star is a type O object. These hot blue stars radiate the bulk of their photons in the invisible



THE SPECTRUM TELLS THE TALE: a glance at the narrow hydrogen (H) lines in the spectrum of Deneb in Cygnus shows it to be a supergiant. Likewise, the wide spectral lines belonging to Theta Leonis are just as characteristic of a dwarf main-sequence star.

ultraviolet. If we apply a correction to include *all* the energy the star emits (not just its visual part), HD 93129A's total radiance comes near absolute magnitude –12, making it 5 million times more luminous than the Sun. This star is invisible to the eye only because it is some 11,000 light-years away. If placed at the standard 32.6 light-years, it would rival the Full Moon in brightness.

Stars of a Feather

These supergiant stars do not reside just anywhere in the sky. All of them in the table lie along the Milky Way. This broad glowing band is made of the combined light from the stars in the disk of our Galaxy, which also contains the gas and dust out of which new stars are forming. More telling, supergiants of all kinds have a powerful propensity to congregate together — that is, to form associations. These groups are called OB associations because they are rich in O- and B-type stars. The associations are usually named after their principal parent constellations: Cygnus OB2 #12, for example, is the 12th star in the second OB association in Cygnus.

Probably the best known of all associations is Orion OB1. It consists of Rigel plus the B supergiants Zeta and Epsilon in the belt and Kappa, Orion's right leg. Then add the O stars: the third belt member Delta, Lambda in Orion's head, Theta[1] of the sword, Sigma, Nu, and Flamsteed's 1 Orionis. Most of the constellation is in fact one grand nearby association. Much the same can be said about Scorpius, where Sco OB1 contains Antares, Delta, Beta[1], and Tau Scorpii.

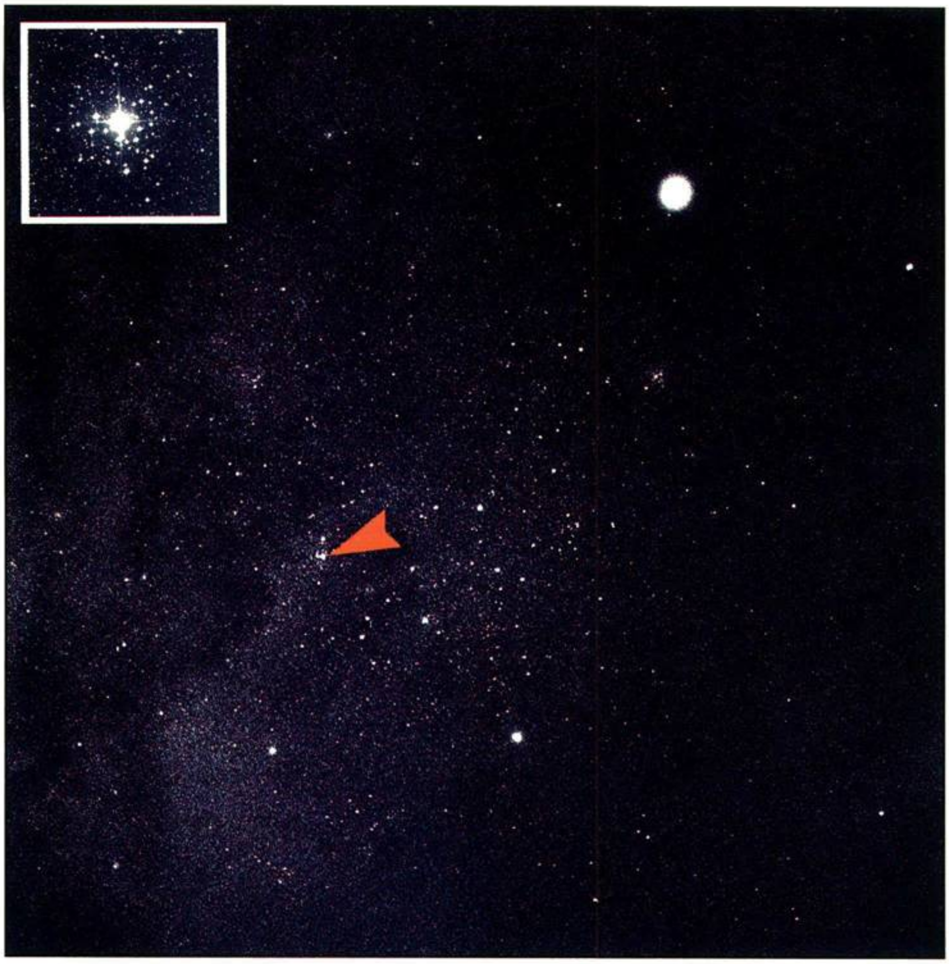
The stars of a given association must have been born together out of a common cloud of interstellar matter. And yet they are not bound together gravitationally; the stars drift away from one another. Since the supergiants are still found together, they must have very short lives, a result of their immense masses. These stars live their entire lives before they can wander very far from their places of origin. These groupings are splendid but their glory is fleeting.

Of the O and B supergiants, only Rigel lies nearer than 1,000 light-years; these stars — or at least their associations — must be far apart and therefore quite rare. By careful count we find that 72 percent of all Galaxy stars are red dwarfs, but that O stars constitute only a bare 0.00004 percent. Why? Part of the reason is their short lifetime, but there's more: nature does not like to make really massive stars, ones with masses dozens of times greater than the Sun's. For reasons that astronomers still do not comprehend, interstellar clouds prefer to make low-mass bodies. Why then study these rare beasts? Because they are so bright that they can be seen at immense distances and can be used to chart our Galaxy. They can be observed even in fairly distant galaxies (see page 36), which helps to establish intergalactic distances. Lastly, they erupt in the devastating explosions of supernovae, which scatter newly formed heavy atoms into the cosmos, thus powering galactic evolution and creating some of the matter out of which we ourselves are made.

Clues in the Light

How can we tell if a star is a supergiant? After all, in your telescope's eyepiece, Rho Cassiopeiae looks like any bright star. Astronomers have two ways: by using known distances to relate the star to others and by analyzing the star's spectrum.

Around the turn of this century, American astronomer Antonia Maury noted that some stars' spectra had sharp or narrow lines (see above), although neither she nor anyone knew just what it meant. More or less at the same time, however, Danish astronomer Ejnar Hertzsprung discovered that these stars had very low proper motions. That is, they were moving much more slowly across the sky relative to their neighbors than were stars with broader spectral lines. Thus, on the average, the narrow-line stars had to be much



OUTSHINING ITS SURROUNDINGS, the 4th-magnitude supergiant Tau Canis Majoris blazes forth from the open cluster NGC 2362 (arrow and inset).

more distant than the others and consequently, because they appeared bright in our sky, the stars had to be extremely luminous. Astronomers quickly dubbed them supergiants.

The spectra of some of these stars show emission lines in addition to the normal absorption lines. The emission lines come from a cloud of low-density gas surrounding the star, which indicates that it is losing mass. The rates of mass loss can be remarkably high: Zeta^1 Sco has been measured to blow off mass at a rate of one solar mass in only 20,000 years. Given even the abbreviated lifetimes of these stars, a stellar wind that blows at such a rate means that an individual star can lose many solar masses over an astronomically short time. In reducing its total mass to perhaps half of its original amount, such a star will profoundly change its appearance. Some stars even have nebulosity visible around them, gas blown away to large distances that is illuminated by the ultraviolet radiation of the hot star left behind.

A leader among windy hot stars is P Cygni, a remarkable body that is evaporating into space at a vigorous rate of one solar mass every 2,500 years. The outflowing wind is so dense that it produces distinctively shaped spectral lines, which have come to be called P Cygni lines. Instead of a simple absorption or emission spectrum, P Cygni type stars show a combination of the two, with an emission line flanked to the short wavelength side by an absorption feature (see opposite).

The explanation for this is simple. A stellar wind streams out in all directions in a great flow. Most of it produces strong emission lines that are superimposed upon the normal stellar spectrum. The gas generating this emission is on the whole blowing across the line of sight, so its spectral lines show little Doppler shift in wavelength. Part of the gas, however, stands directly in our line of sight to the star, which causes an absorption line. Because this gas is flowing directly toward us, the absorption line is Doppler-shifted toward shorter (bluer) wavelengths. The result is a sharp absorption next to the emission.

P Cygni lines can paint a striking picture of the conditions in the star's outer layers. By measuring the Doppler shift in the spectral lines relative to their laboratory wavelength astronomers can deduce the velocity of outflow. And by studying the strength of the lines, we can gauge the amount of material shed.

Peekaboo Stars

The cool giant and supergiant stars are prone to both regular and irregular changes in size and brightness. (See my articles in the May and October 1990 issues.) The hotter stars, however, generally do not undergo such fluctuations. Night after night, Deneb and Rigel will appear constant. However, some of the most luminous stars *do* exhibit some very strange behavior. Not only can their brightness change greatly, but their spectra can alter dramatically as well.

An intriguing case is Rho Cassiopeiae, now a yellow-white F8 supergiant faintly visible to the naked eye at magnitude 4.5. Since 1900 the star has shown irregular variations in which it fluctuates a few tenths of a magnitude and its spectrum wanders from type F to the cooler type K. Over a period of 10 months starting in 1945, Rho declined to 6th magnitude, developed bands of titanium oxide in its spectrum, and turned itself into a cool, red M3 star! It stayed in this state for 6 months and then over another half year returned to normal. In truth, Rho Cas played us a trick. For reasons still known only to itself, it began a period of rapid mass loss that reached a rate of perhaps 1/10,000 of a solar mass per year (which is high) and simply hid within a self-created thick, dusty cocoon. The M spectrum we saw came not from Rho Cas itself, but from the cool surrounding shell.

Stars like this are rare indeed, but they are so enormously luminous that they can be seen for immense distances. Consequently we know where many of them are. A much stranger example of this phenomenon may be Eta Carinae (page 32), the centerpiece of the great nebula that shares its name. This giant cloud of gas, easily visible to the naked eye, marks a region rich in massive stars, of which Eta may be a champion example. The star itself is now just barely visible to the naked eye, but in 1844 it was second only to Sirius in apparent brilliance. What a remarkable sight it must have been to see Sirius, Canopus (Alpha Carinae), and Eta all together in the sky! But by 1856 Eta had faded to 7th magnitude and (excepting for a brief eruption) has brightened only a bit to 6th magnitude.

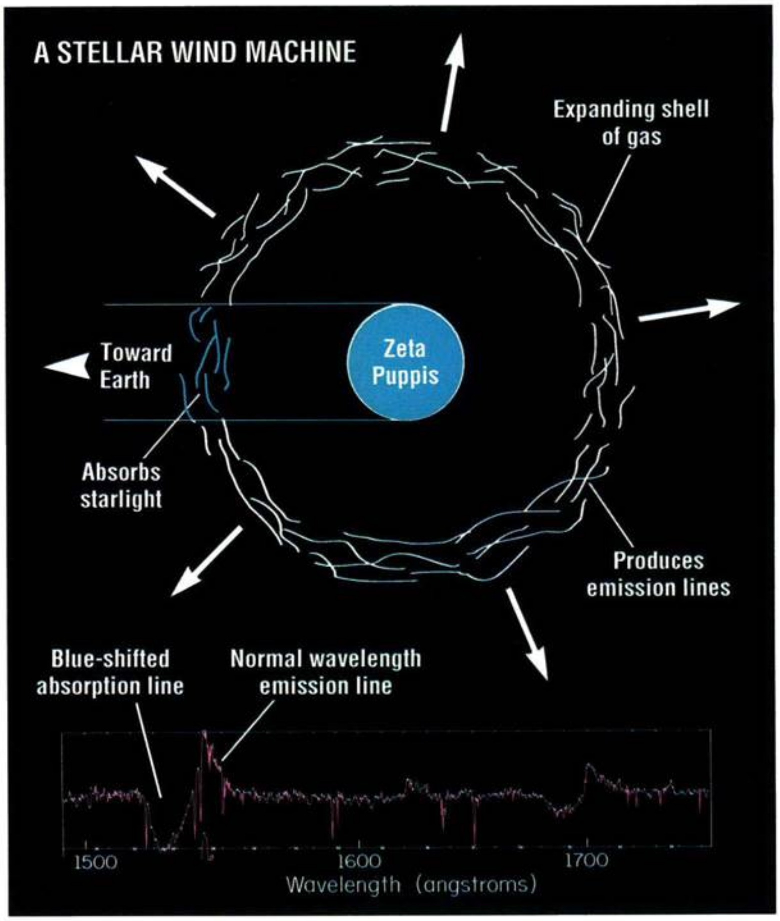
Unfortunately, no devices were capable of recording the star's spectrum in the 1840s, but by the 1890s the spectrum was roughly class F. Now, however, Eta's stellar spectrum is gone — all that can be seen is the emission spectrum from a tiny, dense gas cloud called the Homunculus Nebula. Astronomers think Eta Carinae may actually be a type B star in masquerade. Over a century ago, it underwent a gigantic outburst, sloughing off its outer layers. This remarkable episode of mass loss may have reached a rate of a thousandth of a solar mass per year, tenfold greater than that of Rho Cas. The expanding cloud was thick enough to hide the B star and cool enough to appear as class F. Over the past century, the cloud has expanded to become a thick, dusty nebula that exhibits emission as it absorbs and reradiates the energy radiated by the ferociously brilliant star concealed within.

Another example of this kind of variable — each of which has quite distinctive characteristics — is P Cygni, the star that gave its name to the spectral features that typify mass loss. P Cyg was actually recorded as a nova in the year 1600. Real novae, however, result from explosions caused by the transfer of mass from a main-sequence star to a white-dwarf companion. Astronomers have come to think P Cygni's "nova" in 1600 was more likely akin to Eta Carinae's event of the last century.

Stars of this strange category are so rare that astronomers must examine them in other galaxies in order to find enough to study. A wonderful example is S Doradus, one of the most luminous stars of the Large Magellanic Cloud. How bright is it? Though S Dor lies 150,000 light-years away, it still shines at 8th magnitude and is visible in binoculars. Four other immensely luminous variables were found in M33, the big Triangulum spiral galaxy, 35 years ago by Edwin Hubble and Allan Sandage; they labeled them simply as variables A, B, C, and 2 (see page 36). These stars are faint to us on Earth — only 18th magnitude or so — but they are among the brightest in this nearby galaxy, which lies some 2.5 million light-years distant.

Modern instruments have actually allowed us to examine the behavior of the Hubble-Sandage variables in considerable detail. They, too, appear to be hot supergiants with shrouds that mimic the spectra of cooler stars. Variable C, for example, has decade-long episodes of brightening about every 40 years or so. Variable A, rather like Rho Cas, turned from an F to an M star in just a year while dimming by 3.5 magnitudes.

It has become quite apparent that this diverse set of stars is really a loose family termed "luminous blue variables," despite their apparent color, which is often reddish. In their centers beat fiercely the bright blue hearts that produce so much energy the stars are literally tearing themselves apart. The mechanism appears to be simple radiation. Light exerts a pressure whenever it is reflected or absorbed. The effect is so small under ordinary conditions that we are quite unaware of it; we feel nothing, for instance, if someone shines a flashlight upon us.

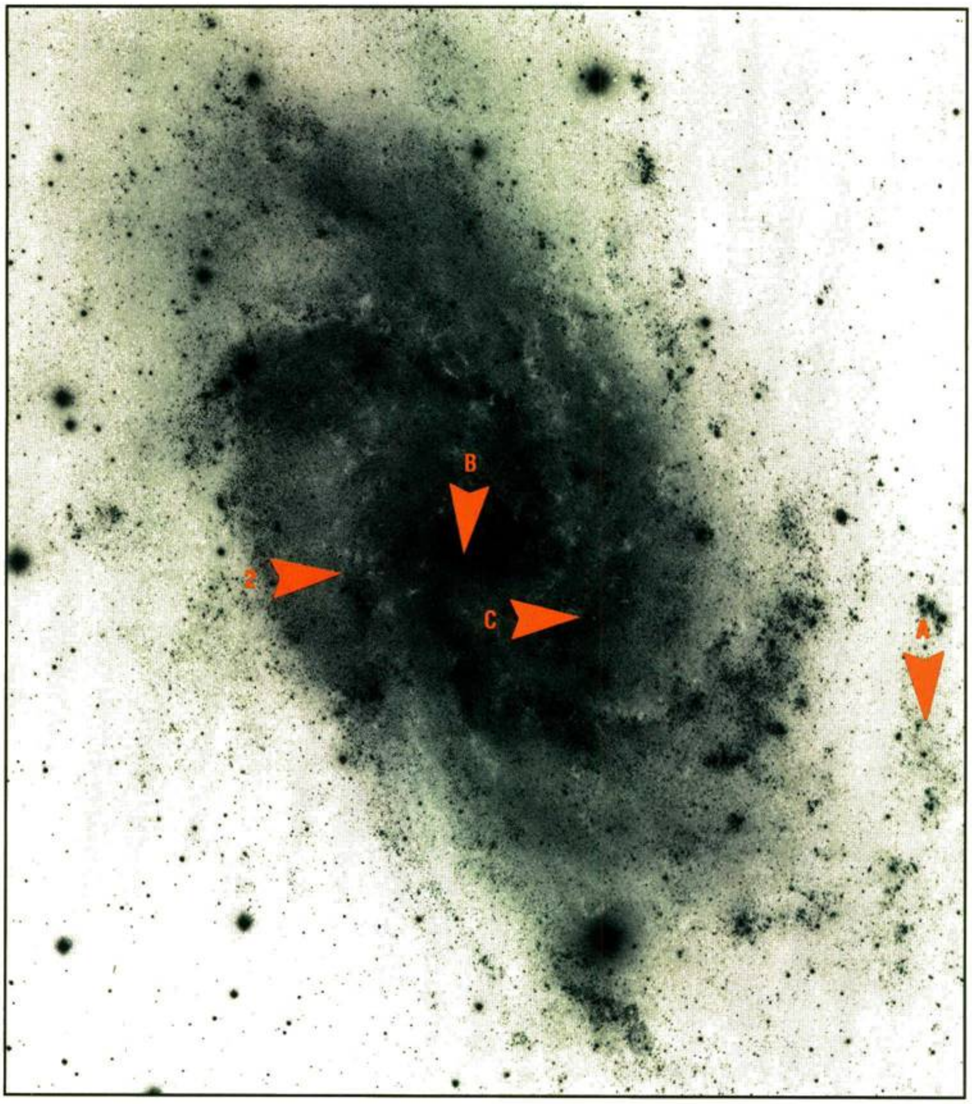


VEILS OF DISCARDED STAR-STUFF surround the supergiant Zeta Puppis and impose a distinctive "signature" on its spectral lines. The gas racing directly toward us is Doppler-shifted to the blue and absorbs light from the star, while the rest of the shell glows in emission with a velocity that averages zero.

But a star like the Sun is stable only because at any point the inward pull of gravity is just balanced by the outward pressure produced by the hot gas and by radiation. As the mass of a star increases so do its central temperature and luminosity and the rate at which it burns its nuclear fuel. At some point the amount of radiation increases so much that its pressure exceeds the ability of gravity to hold the star together — and the star begins to shed its outer layers. The luminous blue variables are near the upper limits of what is allowed and are evaporating because of it.

Where the Fierce Star Winds Blow

Even stranger than the luminous blue variables are the Wolf-Rayet (WOLF-rye-YAY) stars. Named for a German and a French astronomer, these are luminous, hot supergiants with temperatures like those of O or B stars. But they do not really belong to these



SUPERGIANTS EARN THEIR NAME! Even from 2.5 million light-years away, astronomers can identify four luminous blue variables (A, B, C, and 2) in the Triangulum galaxy M33. Photo courtesy Palomar Observatory.

classes, for they have eccentric spectra, which show only emission lines and no significant evidence of hydrogen, normally the most common element in a star. Wolf-Rayet stars are losing mass at such high rates — one Sun's worth every 10,000 to 100,000 years — that all we see is radiation from their winds, in which the dominant element is helium.

The Wolf-Rayet stars come in two broad categories, carbon-rich (WC) and nitrogen-rich (WN). The latter have enormously elevated levels of nitrogen, with normal amounts of carbon and oxygen. The WC stars are greatly enriched in carbon and oxygen but contain almost no nitrogen at all. The stars have apparently blown off their outer hydrogen envelopes to expose layers rich in the by-products of different kinds of nuclear burning. With a Wolf-Rayet star, such as 2nd-magnitude Gamma Velorum, we in effect have a thermonuclear furnace laid bare, practically before our eyes.

Down the Corridors of Space and Time

Piece by piece, astronomers are using the theory of stellar evolution to assemble a synthesis of all types of stars. In the realm of the supergiants, however, computer star models are beset with severe difficulties. One of the worst is the loss of material that makes these stars so observationally odd. Mass loss changes the internal characteristics of the stars and, confusingly, alters the way in which they evolve. Worse, we cannot predict in advance how rates of mass loss can change with time.

Nevertheless, the clouds of ignorance are beginning to clear. All luminous supergiants have evolved from main-sequence O and B stars. As such a star's hydrogen fuel fuses to helium, it begins to redden a bit toward cooler spectral types, giving breadth to the main sequence. Eventually all its useful hydrogen is consumed, the pace of evolution speeds up, and the star becomes a red M-class supergiant. It then begins to evolve back, perhaps returning to class B or O again, but now much changed inside. As the expanded envelope collapses slightly and heats the star, its helium begins to fuse into carbon, keeping the luminosity high. Then carbon begins to fuse in its turn, and on and on the process goes as ever-heavier elements are created and fused. Astronomers are not yet certain exactly where and when these stages occur. But isn't it delightful to realize that Antares and Betelgeuse were once as blue-white as the stars of Orion's belt — and may be once again?

Evolution proceeds in a way that depends critically upon a star's birth-mass and how fast it sheds material. A powerful clue is provided by observation of the brightest stars. Which are the brightest of all? As far as we know, they are HD 93129A, Cyg OB2 #12, P Cyg, and Zeta^1 Sco — all type B stars (which may include Eta Carinae as well). The other (cooler) supergiants are simply not so luminous. From spectral type A (hot) down to spectral type M (cool), the brightest known stars all average about –9.5 magnitudes or so.

This fundamental fact appears to indicate that a kind of upper boundary to stellar luminosity exists for these spectral types. Sometimes called the Humphries-Davidson limit, this boundary says that stars having initial masses below 50 to 60 times that of the Sun can evolve to become red supergiants. The O stars with higher masses, however, cannot.

The luminosity limit is set by the strong radiation from the star and by increasingly violent pulsations that would tear the star apart if it tried to get brighter. And what do we see at or just beyond the limit? Stars such as Eta Carinae and P Cygni, both of which are furiously

THE BRIGHTEST STARS IN THE MILKY WAY

These are the Galaxy's most luminous stars, listed in descending order of temperature.

Star	V	Spectrum	M(v)	M(bol)	Location	Distance	Properties
HD 93129A	7.03	O3	–7.0	–12.0	Carina	11,200	P Cygni type
Tau CMa	4.40	O9	–7.0	–10.1	NGC 2362	2,900	binary
Cyg OB2 #12	11.5	B5	–9.9	–10.9	Cyg OB 2	5,700	10 magnitude extinction
Eta Car	7	B?	?	–11.5?	Carina	8,200?	outbursts
P Cyg	4.81	B1	–9.0	–10.7	Cyg OB1	5,900	loses 1 solar mass in 2,500 years
Zeta^1 Sco	4.73	B1.5	–8.7	–10.8	Sco OB1	5,000	loses 1 solar mass in 20,000 years
Rigel	0.12	B8	–8.4	– 9.0	Ori OB1	850	
Deneb	1.25	A2	–8.4	– 8.6	Cyg OB7	1,500	loses 1 solar mass in 3 billion years
6 Cas	5.43	A3	–8.3	– 8.4	Cas OB5	6,000	shell star
IRC +10420	?	F8 to G0	?	– 9.2 to –10.2	Aquila	15,000?	dust-enshrouded star
Rho Cas	4.54	F8	–9.5	– 9.4	Cas OB5	8,000	odd variable
HR 8752	5.10	G0 to G5	–9.3	– 9.3	Cep OB1	12,000?	varies 0.4 magnitude, has a shell
RW Cep	6.65	K0	–9.4	– 9.6	Cep OB1	11,500?	
VX Sgr	7 to 11	M4 to M8	?	–9.5 to –10	Sgr OB1	5,000	732-day long-period variable
Mu Cep	4.08	M2	–8.0	– 9.5	Cep OB2	1,700	semi-regular variable

V = visual magnitude; M(v) = absolute visual magnitude; M(bol) = absolute bolometric magnitude (all wavelengths); Distance = light-years.

casting off material. It is possible that the luminous blue variables are in the throes of becoming Wolf-Rayet stars as they strip their outer layers away. Therefore the Wolf-Rayet class might be the unstable, doomed progeny of the highest-mass stars.

Powerful additional evidence comes from observations of double stars. Wolf-Rayet stars in binaries are always tied to type O companions. From the Doppler shifts seen in the spectral lines as the two stars swing around one another, astronomers infer a mean mass for Wolf-Rayet stars of about 20 times the Sun's. This number is not really all that high. Yet both stars in the pair must have formed together, and if the Wolf-Rayet was the first to evolve in the double system, it must have been initially the more massive one of the pair. From the masses of the O star companions, we know that the Wolf-Rayet stars evolve from near the top of the main sequence and must have lost at least 40 percent of their original masses — and maybe much more. How better than as a luminous blue variable?

Recall that Wolf-Rayet stars come in two distinct classes, one nitrogen-rich, the other with a wealth of carbon and oxygen. This fact may be explained by evolution, with the nitrogen-rich stars evolving into carbon-rich. How? Hydrogen burning in type-O stars proceeds via the carbon-nitrogen-oxygen cycle in which carbon acts as a nuclear catalyst in the creation of helium. As part of the cycle, carbon absorbs a proton and converts to nitrogen. In the star's burning zone, the nitrogen-to-carbon ratio should grow.

This is roughly what astronomers find, as mass loss strips the outer layers away to reveal the byproducts of the first nuclear-burning stage. Helium-burning, the next stage, goes by the triple-alpha process in which three of the helium atoms formed by the carbon cycle are converted to one atom of carbon. As a star evolves, we would expect its surface would become enriched in carbon and that nitrogen would effectively disappear — just what is seen. This picture sounds quite convincing, but serious uncertainties remain. For example, we see no Wolf-Rayet stars that fall between the two classes and, more importantly, the carbon-rich stars don't appear to have smaller masses than the nitrogen-rich ones, as would be expected given the ongoing mass loss the process demands. It is possible that the two kinds of Wolf-Rayet stars simply evolve from objects of different masses.

In any case, the end result of supergiant evolution is likely to be a supernova. Nuclear burning in the star's core proceeds by successive stages of nuclear fusion until iron is produced. But iron is a thermonuclear dead end because it cannot fuse to a heavier element. When fusion reaches iron, therefore, the reactions come to an abrupt halt and the star's central energy supply shuts down. Lacking the energy to support the overlying layers, the star's core suddenly collapses, the gravitational energy of the in-falling layers turns to heat, and the outer layers of the star explode. In a blinding flash of light that can briefly rival the brightness of its home galaxy, the star dies in a blazing inferno visible from billions of light-years away. When the debris clears, astronomers may find an expanding cloud of gas with a dense neutron-star core.

But this evolutionary picture is still highly puzzling. We might expect that most supernovae would come from Wolf-Rayet stars. Yet when supernova 1987A exploded in the Large Magellanic Cloud, it was an ordinary-seeming type B supergiant, known prosaically as SK –69° 202, that blew up. Even as they now sort out their observations, years after the event, astronomers — and we — realize that true understanding has barely begun. □

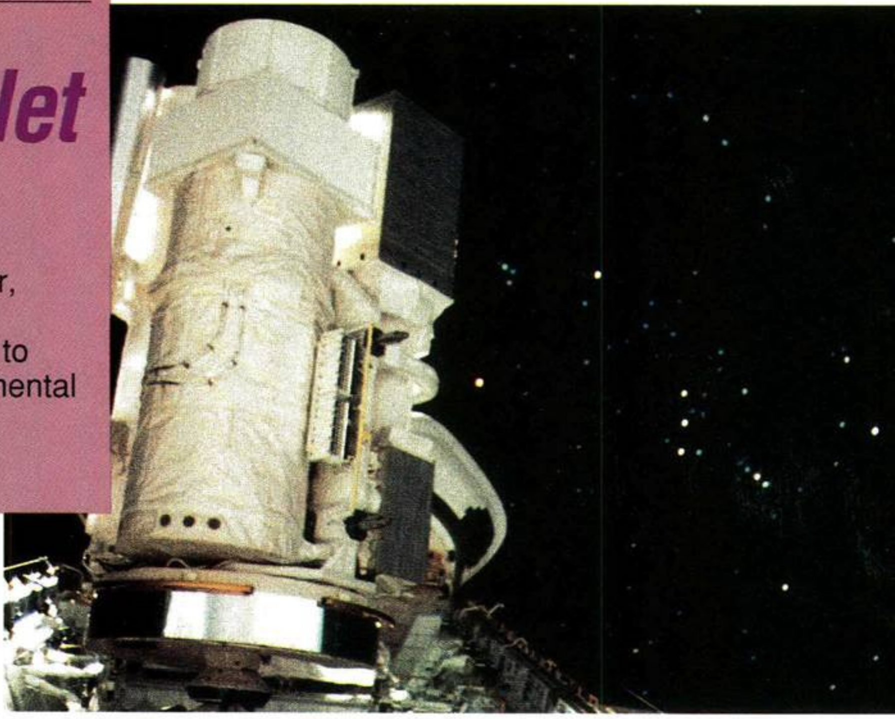
James B. Kaler is a professor of astronomy at the University of Illinois. His last article in ASTRONOMY was "The Largest Stars in the Galaxy" in October 1990.

ASTRONOMY FROM ORBIT

Astro's Violet Universe

For nine days last December, astronomers used a shuttle-borne observatory to attack some of the fundamental questions of the universe.

by Terry Devitt



THE STARS OF ORION form a backdrop to the bank of Astro telescopes on board the shuttle Columbia. NASA photo.

It's been a good morning in the science operations area. The observatory aboard the space shuttle Columbia is operating smoothly. Astronomers are glued to banks of consoles at Mission Control, intent as a supergiant star called P Cygni moves into view.

It is December 5, 1990, four days into the Astro-1 mission. For four teams of astronomers crammed into a narrow, cluttered room at the Marshall Space Flight Center in Huntsville, Alabama, the mission has been a frenetic roller coaster ride of emotions. Technical failures have given an edge to a mission that astronomers knew would clearly be nothing like observing with telescopes here on Earth.

For the next 33 minutes the telescopes in Columbia's 60-foot cargo bay will be locked onto a star that has piqued the curiosity of astronomers since it was first seen to erupt almost 400 years ago. Some 75 times more massive than our Sun, P Cygni is thought to be blowing off its outer layers and building a cocoon of dust around itself.

"This is the kind of star that can go supernova," explains MaryJane Taylor, a University of Wisconsin-Madison astronomer and a member of the science team for one of Astro's four telescopes. "It happens to be in a phase of evolution where it's getting rid of some of its mass and we don't know why." The stellar evolution of these early-phase supergiants is one of the scientific programs for Astro's long-awaited payload of one x-ray and three ultraviolet telescopes.

Five Years in the Waiting

For Taylor and the dozens of other Astro astronomers, the mission is the culmination of years of work. First scheduled for launch in 1986 — it was to have been the next mission after the ill-fated Challenger flight of January 1986 — Astro was the victim of numerous delays. In 1990 its launch was scrubbed four times because of the orbiter Columbia's chronically leaky fuel system and other technical problems.

Once in space, Astro miraculously accomplished a major portion of its scientific program despite still more problems. Erratic command systems, automatic pointers unable to home in on targets, and lint-clogged display units all taxed astronomers and support teams at Marshall to the limit. "Any one of those hits could have stopped us," says Astro mission scientist Ted Gull. "But they didn't."

For its nine days in orbit 190 nautical miles above Earth, Astro made almost 400 observations and brought home a feast of data on 135 ultraviolet and x-ray emitting objects. "We didn't get as much as we wanted," remarks Gull, but adds that even so, the $150 million Astro observatory will yield a huge return for astronomy. Since Astro's return to Earth on December 10, astronomers have begun to analyze their treasure-trove of data and have announced some enticing first-look discoveries.

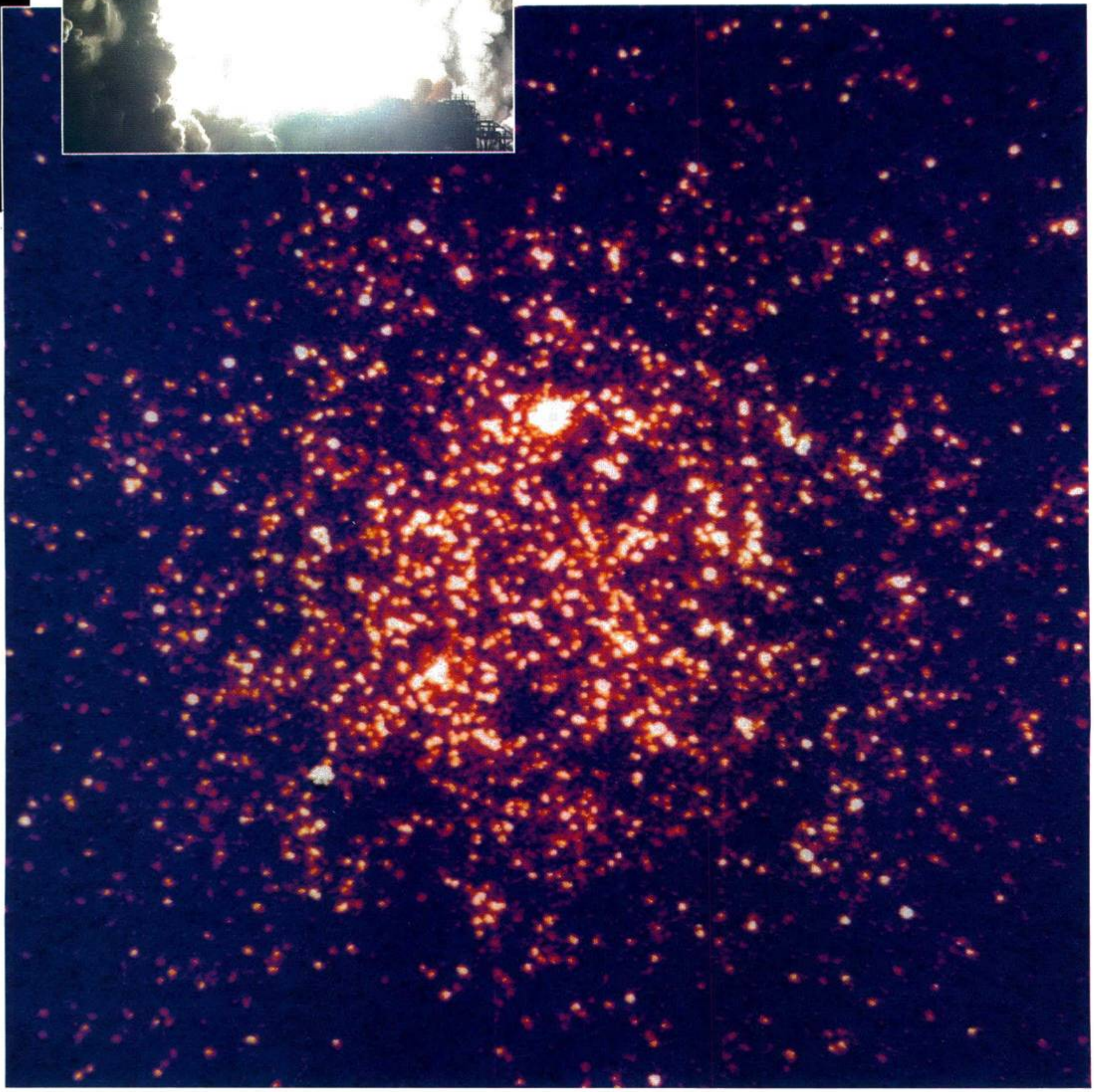
Chasing Ultraviolet Rainbows

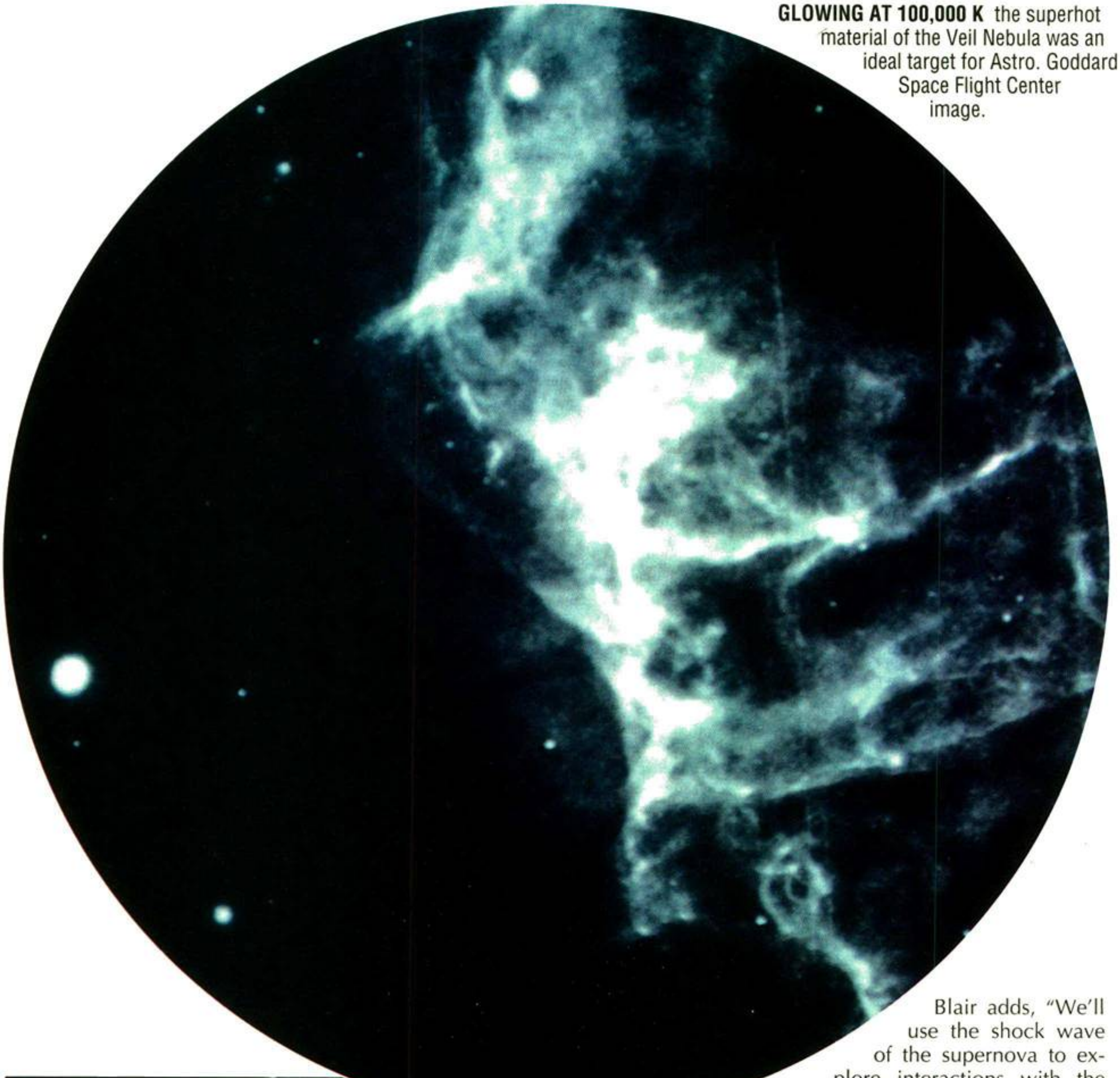
"Astro is showing that instruments of a very modest class are capable of major discoveries," asserts Johns Hopkins University astronomer Arthur P. Davidsen. Davidsen leads the team that built and operated the largest of Astro's telescopes, the 36-inch Hopkins Ultraviolet Telescope, or HUT. Designed to probe the far reaches of the ultraviolet bordering on the x-ray band, HUT doesn't take images. Instead its instruments spread the incoming UV light into a rainbowlike spectrum. Just as with visible light, the intensities and wavelengths of bright features in an ultraviolet spectrum can indicate the composition and velocities of target objects.

For example, Johns Hopkins astronomer Bill Blair used HUT to examine the Veil Nebula, an object 2,500 light-years from Earth. "The nebula is the result of a supernova that exploded thousands of years ago," says Blair. The ancient supernova sent a shock wave into the surrounding space that swept up interstellar gas as it expanded. Using HUT, astronomers found that the shock wave slowed considerably — from a speed of 120 miles per second to 90 miles per second — as it collided with an interstellar cloud.

IT WAS A LONG WAIT. Originally scheduled to fly in 1986, Columbia finally carried Astro-1 skyward on December 2, 1990. NASA photo.

IN THE ULTRAVIOLET the globular cluster Omega Centauri shows a new face. Astro's image reveals a multitude of stars that used to be red giants but have since evolved into hotter, bluer stars. Goddard Space Flight Center image.

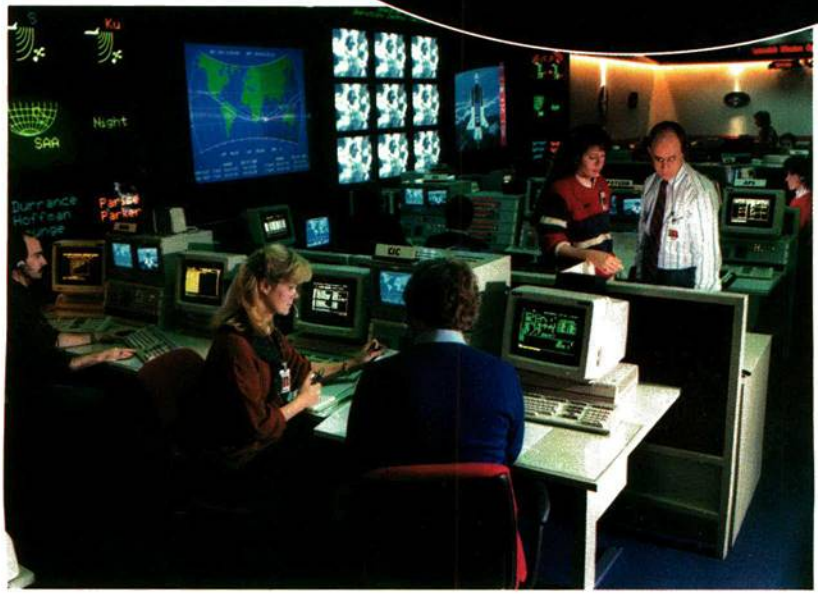




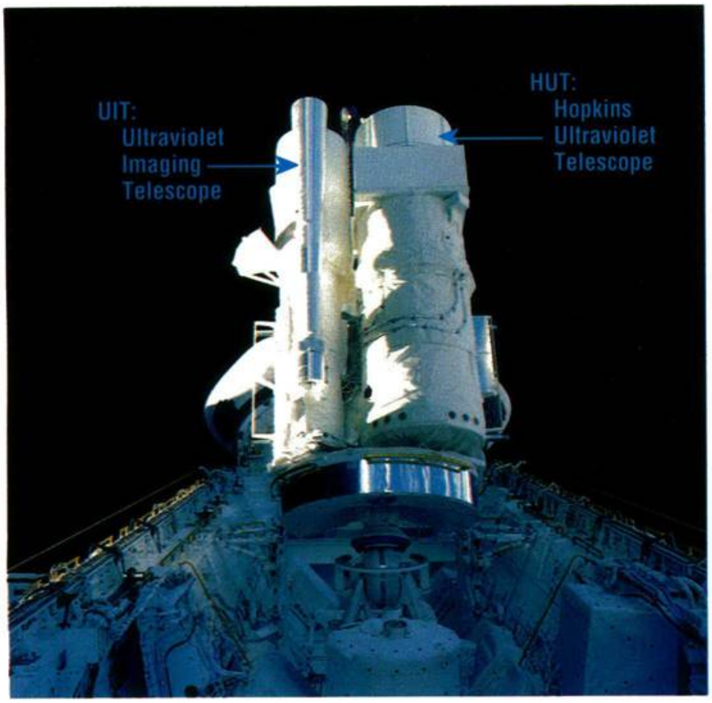
GLOWING AT 100,000 K the superhot material of the Veil Nebula was an ideal target for Astro. Goddard Space Flight Center image.

Blair adds, "We'll use the shock wave of the supernova to explore interactions with the interstellar medium. We hope to determine the temperatures and densities of these normally invisible parts of space."

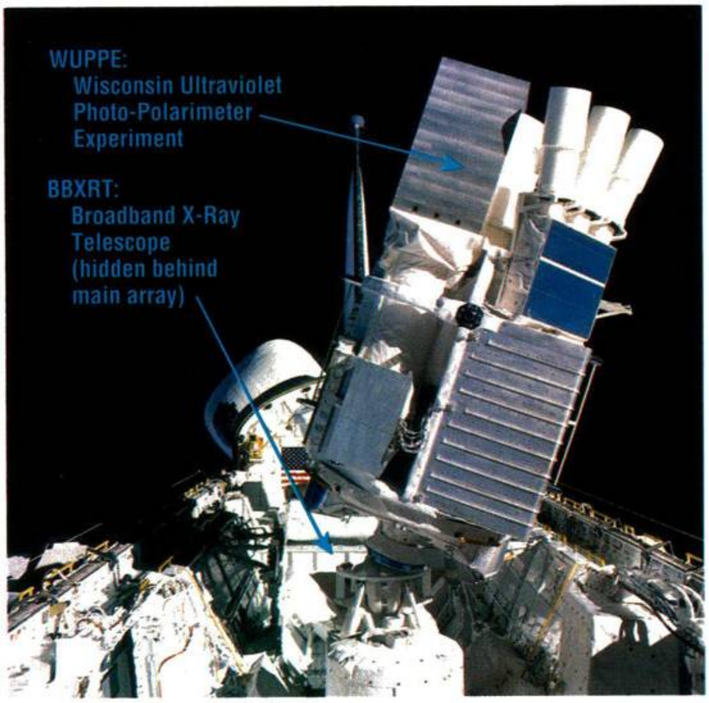
At the same time HUT was dissecting the ultraviolet spectrum of the Veil, the supernova relic was also being photographed by Astro's Ultraviolet Imaging Telescope (UIT), a powerful combination of a 15-inch telescope, image intensifier, and camera. UIT's large field of view (slightly larger than the diameter of the Full Moon) captured a portion of the huge Veil Nebula. The



ASTRONOMERS MONITORED ASTRO *from the ground* using the new Spacelab Mission Control facility at the Marshall Space Flight Center in Huntsville, Alabama. NASA photo.



TWO VIEWS OF ASTRO taken with the main instrument cluster rotated 180° show the three ultraviolet telescopes. The x-ray instrument was mounted separately behind the main cluster and cannot be seen. NASA photos.



resulting picture (left) was among the first released by the UIT science team. It shows the shocked clouds shining brightly in the light of carbon atoms, each stripped of three electrons, an indication that the gas has a temperature of 100,000 K. "By comparing UIT images with visible light photographs of the Veil we can learn how much gas is present at each temperature and how these shock waves propagate through space," explains Theodore P. Stecher, a Goddard Space Flight Center astronomer and UIT's principal investigator.

During the flight, UIT exposed more than 700 frames of sensitive astronomical film, scanning the sky for new objects. According to Stephen P. Maran, a member of the UIT science team, "We are seeing ultraviolet objects that weren't previously known. We can't figure out what they are until we make follow-up observations." These will come later with instruments such as the International Ultraviolet Explorer satellite and the Hubble Space Telescope.

WUPPE's Polarized View

Columbia's high-flying Astro observatory also took extensive measurements of polarized ultraviolet light. To do this astronomers used a 20-inch telescope, the Wisconsin Ultraviolet Photo-Polarimeter Experiment (or WUPPE as it is usually called) built at the University of Wisconsin-Madison.

Polarization is the tendency of light waves to vibrate in a preferred orientation. Light can become polarized, for example, when it is emitted in the presence of a strong magnetic field or when it is reflected off an object. That's why polarized sunglasses can cut the glare from the surface of a road or lake. Measuring the angle and amount of polarization in starlight (a process called polarimetry) in the *visible* parts of the spectrum is itself a fairly new technique. But doing so in *ultraviolet* light is even less common. Arthur D. Code, the Wisconsin astronomer who led the development of the WUPPE telescope, explains that prior to WUPPE's flight, only two stars had been observed in polarized UV light, and those only briefly by sounding rockets. "Every photon that we collected was something new," proclaims Code.

For most of its observations, WUPPE used very bright stars as flashlights to illuminate the interstellar medium. By looking for changes in the way starlight was polarized as it coursed through the clouds of dust and gas between Earth and the star, the Wisconsin astronomers were able to obtain the first detailed evidence of the nature of interstellar dust.

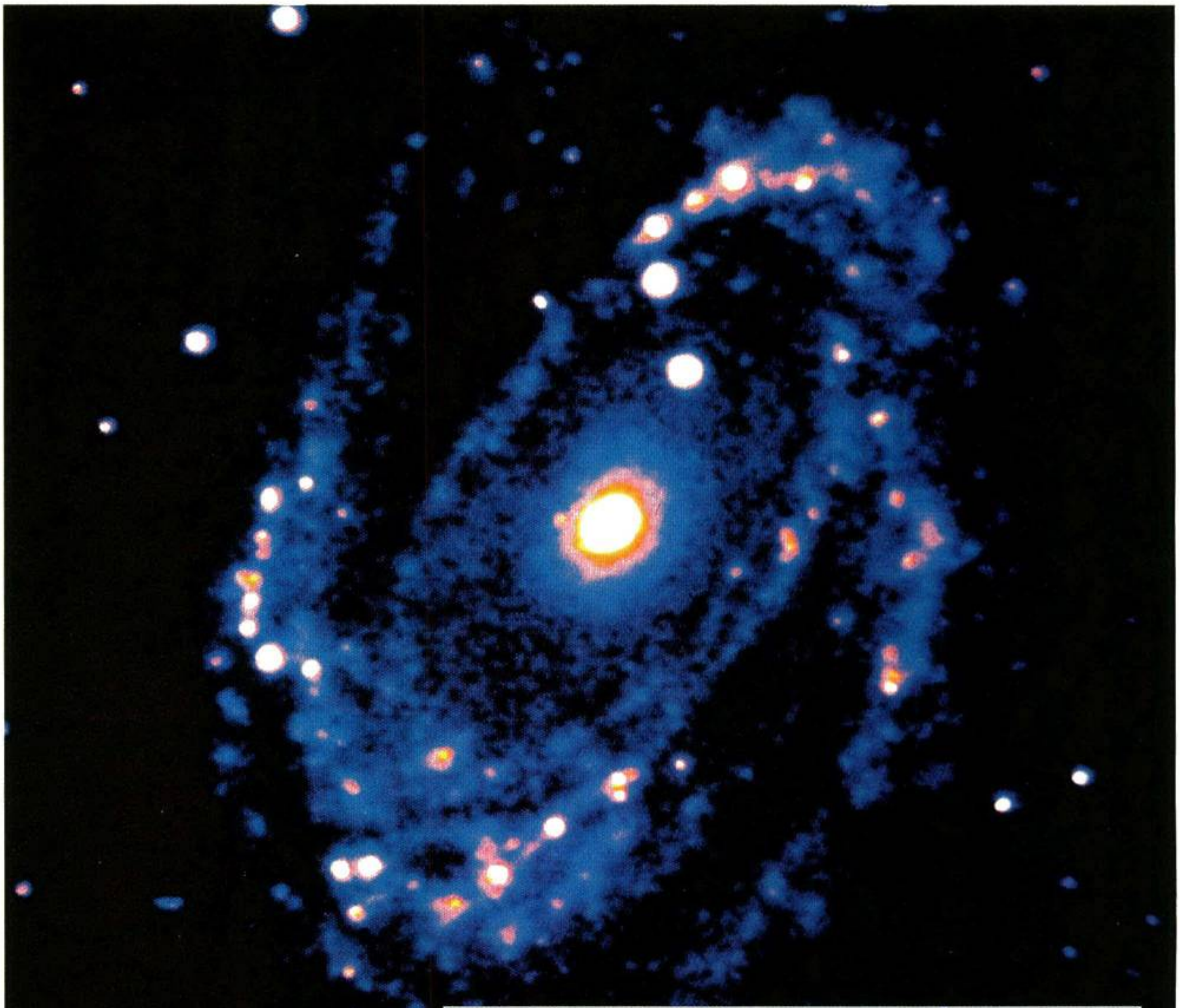
According to Kenneth H. Nordsieck, a Wisconsin astronomer and backup astronaut for the Astro mission, WUPPE data indicate that there are two distinct but intermingled populations of interstellar dust. As previously suspected, one population is composed of graphitelike carbon, a material similar to that used in pencils.

The other seems to be silicates — rocklike substances that are needlelike in shape and contain impurities such as iron. The silicate needles, the astronomers believe, are probably lined up by galactic magnetic fields. This ingredient of the interstellar medium is responsible for the changes WUPPE observed in the polarization of starlight.

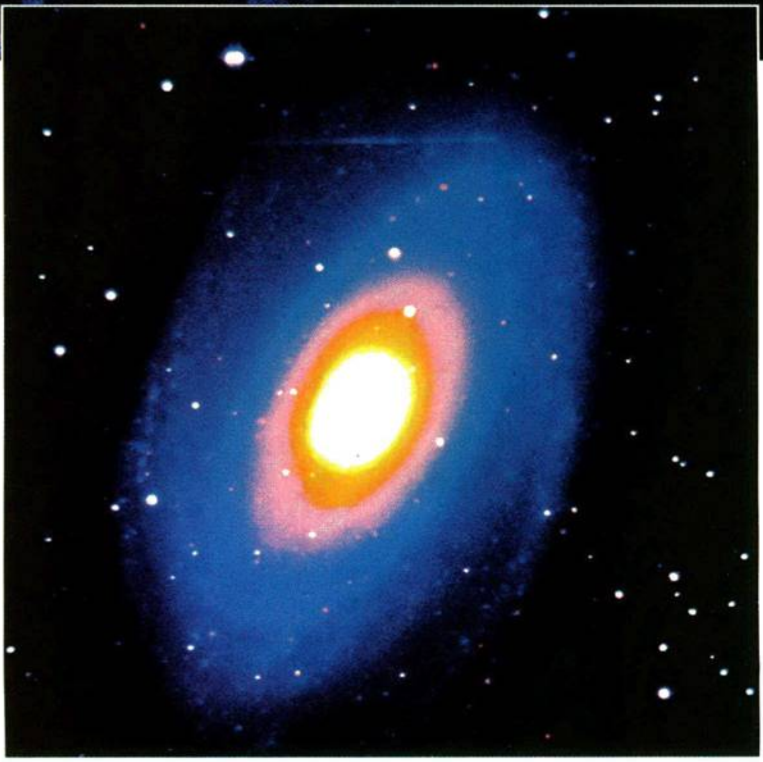
Many interstellar clouds are stellar nurseries, giving birth to new stars as the cloud material collapses into compact objects. A long-standing problem with this picture is that left to themselves, the collapsing clouds would become so hot the collapse would stop. The gas would expand and be driven off into space, putting an end to star formation. But WUPPE has provided a possible answer — the graphite dust could help to cool the proto-stellar nebulae. It might absorb the excess heat, allowing the star-forming process to continue.

Probing a Galaxy's Core

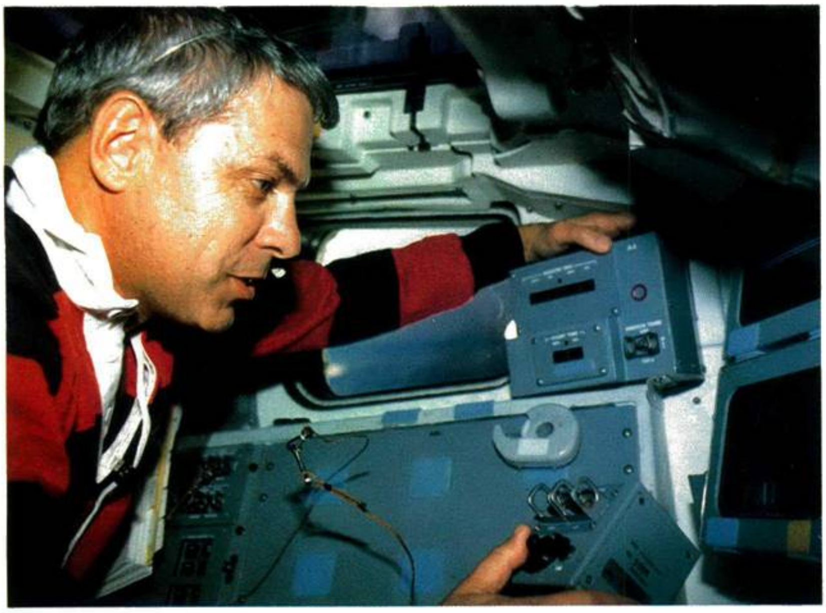
Some of Astro's most tantalizing results were obtained by the observatory's lone x-ray instrument, the Broad Band X-Ray Telescope, or BBXRT. "The preliminary data tell us



GREAT CLUMPS OF HOT STARS and gas dot the spiral arms of the galaxy M81. These are regions where new stars are rapidly forming. Goddard Space Flight Center image.



THE VIEW OF M81 in visible light shows little sign of the star-forming regions revealed by Astro. Kitt Peak National Observatory photo.



WHEN AUTOMATIC SYSTEMS FAILED, mission specialists like Robert Parker had to aim the Astro telescopes manually from the shuttle. NASA photo.

Seeing Beyond the Violet

If our eyes could see only ultraviolet light, everything cool in the universe would be invisible and everything hot would stand out. The sky would be awash in the light of quasars, exploding stars, blue supergiant stars, and energetic galaxies. Seeing ultraviolet light allows astronomers to see ultra-violent events.

Astronomers often measure ultraviolet wavelengths in angstroms. One angstrom equals one ten-billionth of a meter. The ultraviolet band stretches from the shortest wavelengths our eyes can detect, at 3200 Å, to an arbitrary boundary of 100 Å. Wavelengths shorter than 100 Å are considered x-rays.

Seeing the universe at these wavelengths is impossible from the surface of Earth. Our atmosphere effectively blocks ultraviolet and x-rays, a fortunate state of affairs for the safety of life on our planet. For astronomers eager to see the UV universe, it means designing telescopes to fly on high-altitude rockets, orbiting satellites, or in the case of Astro, on manned orbiting platforms.

Results from earlier missions, such as the Orbiting Astronomical Observatories, the Astronomy Netherlands Satellite, and the International Ultraviolet Explorer, indicated that the universe is rich in hot targets that radiate ultraviolet light. Astro's telescopes explored these objects with instruments that were able to see deeper into the ultraviolet spectrum than ever before (down to an unprecedented 425 Å) and with far greater resolution than that obtained by previous satellites. Everywhere Astro looked it saw new things.

we'll be breaking new ground," anticipates Peter J. Serlemitsos, the Goddard astronomer who led the development of the x-ray telescope.

BBXRT was built so that it could detect nearly 100 percent of the incoming x-rays over a broad energy range. Like HUT, it is a spectrum analyzer, not an image maker. Explains Serlemitsos, "Its resolution is high enough that for the first time we can distinguish spectral features from individual elements such as oxygen, silicon, sulfur, calcium, and iron."

During the Astro mission, BBXRT looked at some of the most energetic objects in the universe — quasars and supernova remnants. It found x-ray intensities from the quasarlike galaxy Markarian 335 that matched what astronomers had predicted would be produced by a black hole. The x-rays would be coming not from the black hole itself but from an accretion disk of superhot material spiraling into the hole at the center of the galaxy. But Serlemitsos stopped short of claiming a black hole discovery. "We'll probably never be able to prove there's a black hole at the center, but it's a powerful piece of evidence."

Before the mission, scientists also had set their sights on unraveling some of the mysteries of Supernova 1987A. The death of that star in the Large Magellanic Cloud heated the region of space near the explosion so that it now glows in x-rays. According to Serlemitsos, BBXRT was unable to penetrate the debris around the supernova to actually detect the pulsar which may lie at its heart. "Now we know that the pulsar is much less energetic than originally predicted because we looked at high x-ray energies and saw nothing," he points out. "We also know now how fast the debris [from the supernova] is traveling, but it is still a little early to see through it."

Many of Astro's discoveries are still to come. Its observations of the sodium cloud around Jupiter, of Comet Levy, of mysterious ultraviolet radiation from decaying neutrino particles, and of dozens of other targets are still being analyzed. Promises Stecher, "This is a mission that people are going to hear from. We are going to have a great deal of scientific impact over the next two years."

But the excitement over Astro's success is tempered by the knowledge that the observatory may not fly again. According to NASA's original plans, Astro was to have flown as many as five times on shuttle missions. Now, it is not on the current NASA flight manifest and, according to Astro astronomers, it is almost certain to be mothballed.

"We obviously would like to see it fly again," comments Stecher, a sentiment no doubt shared by all astronomers involved with Astro. With a little luck and a lot of lobbying of NASA by the astronomical community, perhaps Astro's first look at the violet universe won't be its last. ☐

Terry Devitt is a science writer at the University of Wisconsin-Madison and was at the Marshall Space Flight Center during the Astro mission.

HUBBLE DELIVERS

The latest results from HST show just how well astronomers can exploit the telescope's unique capabilities.

by Richard Talcott

Astronomers have experienced a wave of different emotions during the Hubble Space Telescope's first year of life. Their initial great expectations were quickly shattered by the spherical aberration in the primary mirror. But now that Hubble is doing quality science, optimism is slowly replacing depression. Although the worst of times has not yet turned into the best of times, the significant new findings are creating a positive mood.

And HST is no longer just an imaging telescope. Dynamic new images of the universe are sharing center stage with the first spectra taken by the orbiting observatory. These spectra promise to be as valuable as the images in giving astronomers new insights into the workings of the universe.

While much of HST's promise lies in its ability to image distant objects in incredible detail, astronomers are not ignoring Earth's neighbors in space. The space telescope examined many solar system objects during its first year in orbit, but none received as much attention as Saturn. Prompted by the first large-scale atmospheric disturbances on that planet in the last 60 years, astronomers targeted the ringed planet for extensive study.

During three days in mid-November, HST's Planetary Camera photographed Saturn a total of 60 times. The resulting series of images were combined into a "movie" that showed one complete rotation of the planet.

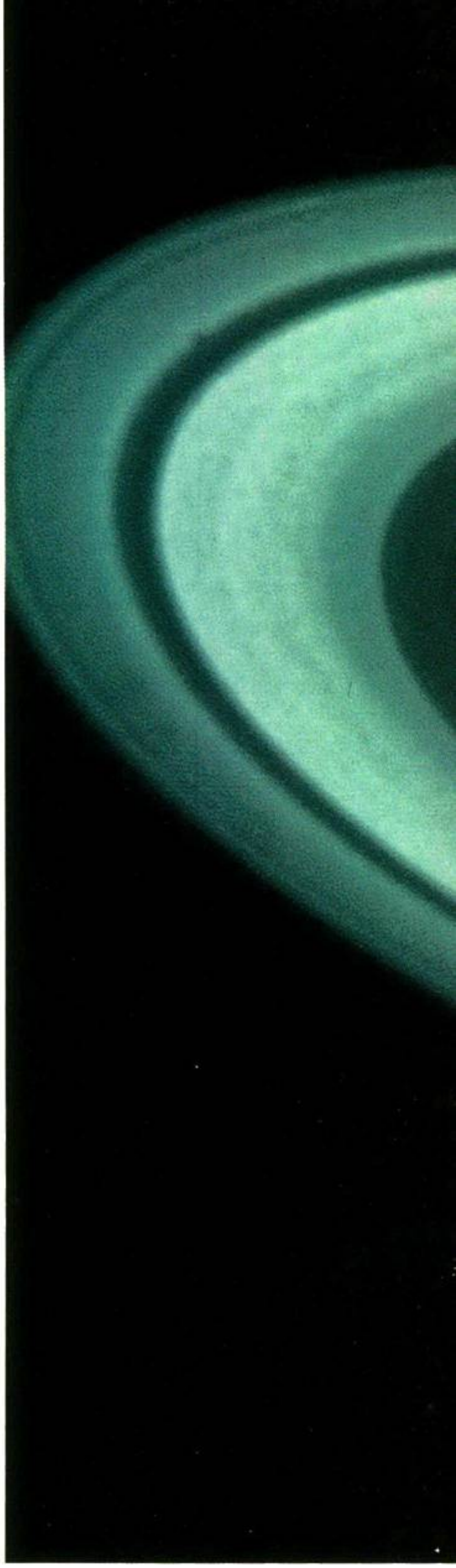
The major storm that ignited interest in making a Saturn movie in the first place erupted in late September, when it was dubbed the Great White Spot because of its shape. By mid-November, however, the spot had dispersed into a high-altitude band that stretched across much of the planet (see images at right). Astronomers analyzing the movie images had two key objectives. First, they wanted to measure the east-west wind speed as a function of Saturnian latitude. Second, they wanted to understand the wave patterns that form in Saturn's atmosphere and compare them with those found in Earth's atmosphere. As we went to press in February, astronomers were still analyzing the collection of photographs.

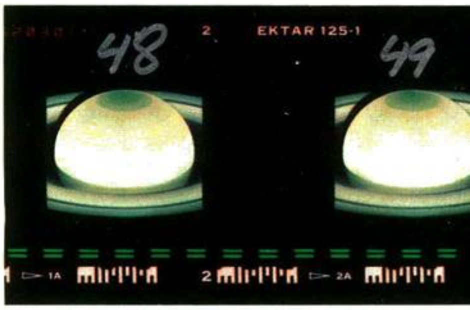
Good-bye to a Black Hole

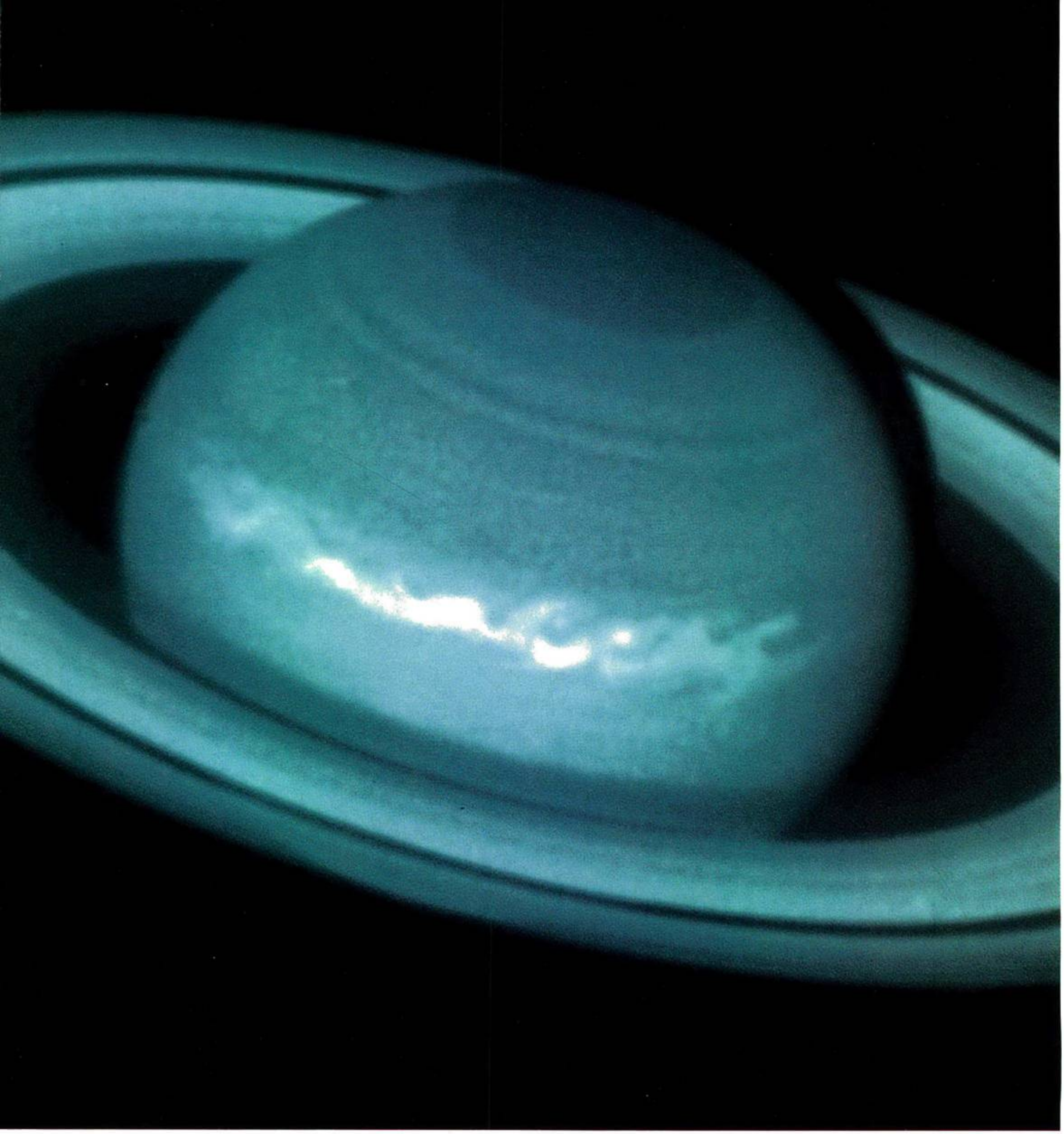
Although the HST images of Saturn promise to enhance our knowledge of that planet's atmospheric dynamics, they have not yet revealed any major surprises. The same can not be said, however, of the highly detailed observations of globular clusters. HST has shown that the core of the globular cluster M15 probably does not contain a massive black hole, as many astronomers had previously believed.

Globular clusters are dense, spherical swarms of hundreds of thousands of stars that are held together by gravity. The Milky Way is home to roughly 125 of these objects, which orbit in the Galaxy's vast halo. M15 rates as one of the largest, containing nearly one million stars. It lies about 42,000 light-years from Earth and is roughly 200 light-years in diameter. Although M15 can be seen in small telescopes from Earth, not even the largest ground-based telescopes can see into the cluster's innermost regions.

The space telescope's Planetary Camera, however, resolves the dense core of M15 clearly. The images (see page 46) reveal that the stars at the center of M15 are packed together nearly a million times more densely than stars in our part of the







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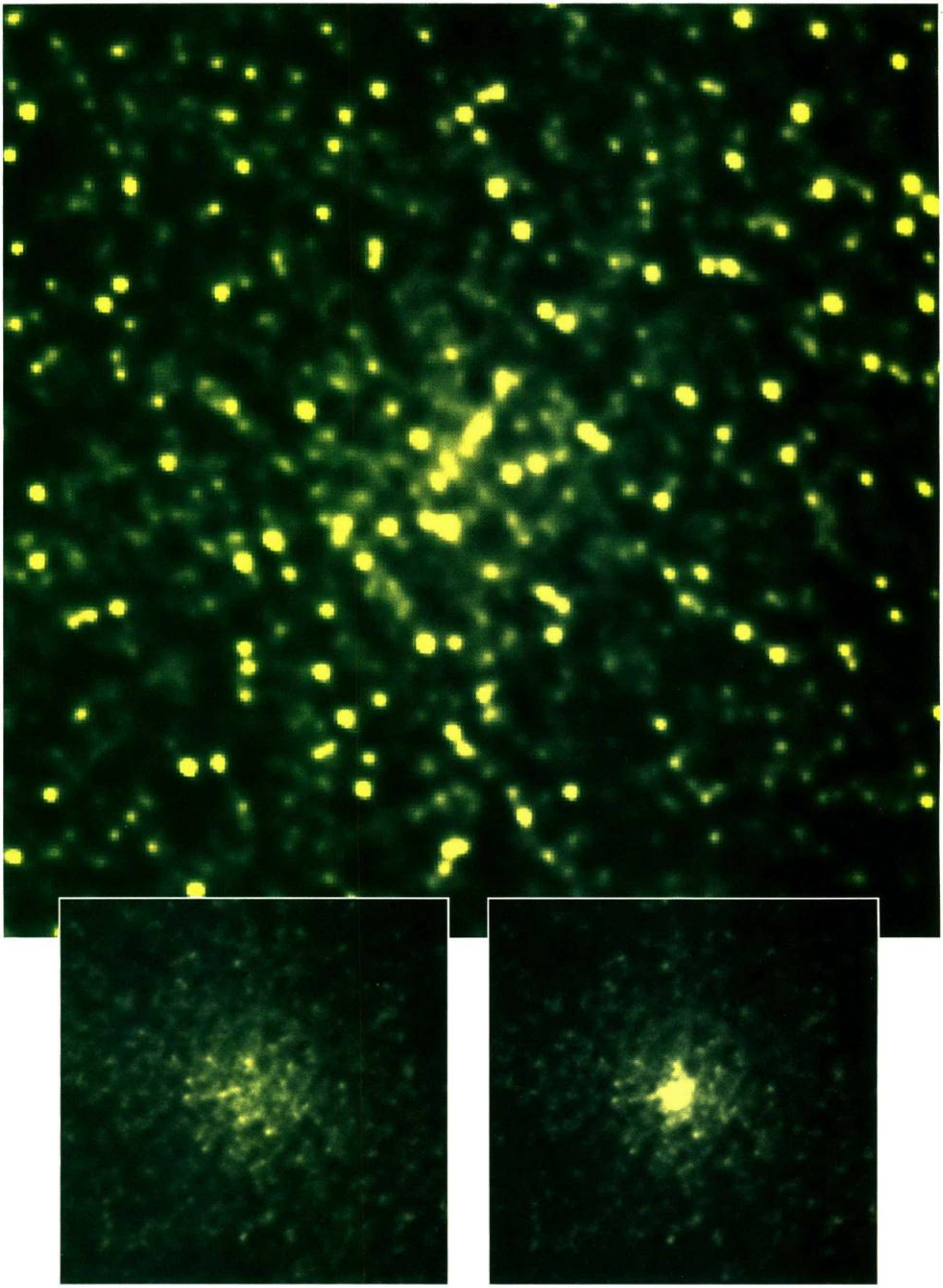
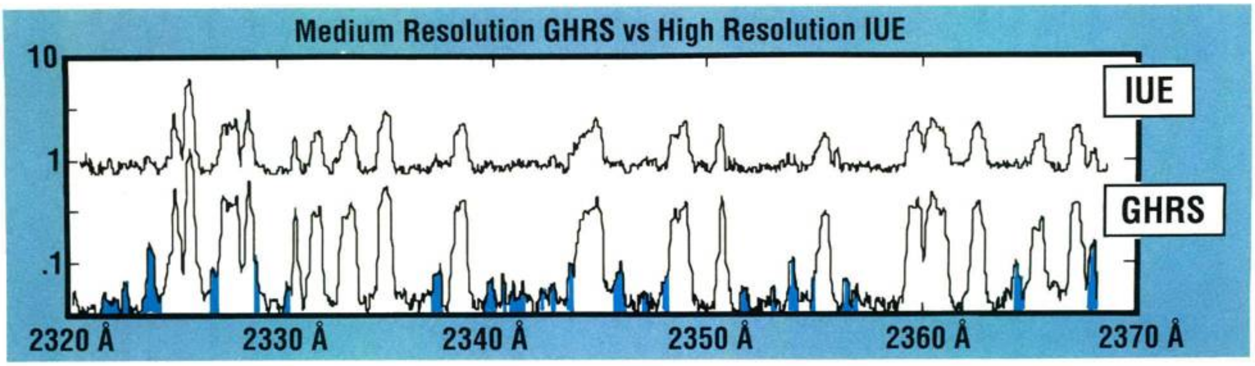
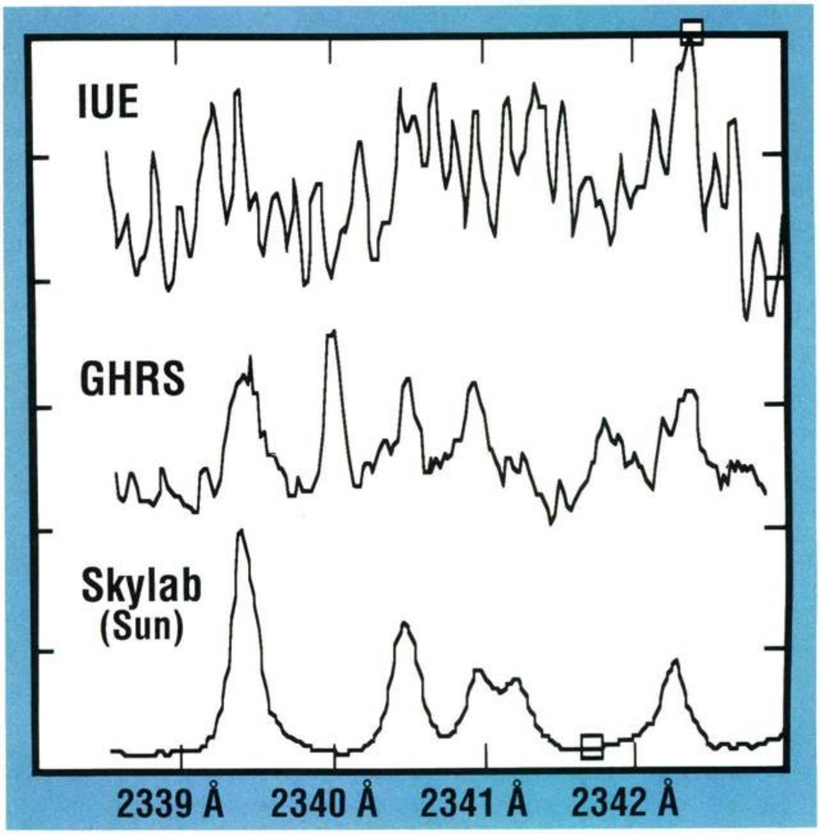
SATURN'S CHAOTIC ATMOSPHERE starred in HST's first movie. A series of 60 photos, of which five are shown here (left), follow the planet through one complete rotation. The large photo (above) demonstrates Hubble's remarkable resolution. NASA photos.



M15'S CORE IS CHOCK FULL of stars in this HST image (top) but is not as dense as it would be if it harbored a massive black hole. Compare the actual cluster's core after the bright stars have been removed (above left) with a simulation of what it would look like with such a black hole (above right). NASA images.



HUBBLE EXPOSES ALDEBARAN in unprecedented detail, revealing more than 20 ultraviolet spectral lines that were unknown from IUE observations (above, with new GHRS spectral features shown in color). With just a 20-minute exposure, the GHRS captured many features that couldn't be seen amidst the noise in a 570-minute exposure with IUE (below). Spectra courtesy Kenneth Carpenter.



Galaxy. At the core of the cluster, nearly 7,000 stars are squeezed inside a volume only 0.8 light-years in diameter. In contrast, a sphere centered on Earth having a thousand times that volume would contain only one star — the Sun.

The M15 images also give astronomers an unprecedented view of the evolution of the cluster. M15's high density guarantees that stars will occasionally pass near one another as they orbit the cluster's center. When this happens, one of the stars loses energy and the other gains energy. The star that loses energy sinks deeper into the cluster, while the one that gains is flung outward. Stars with more mass tend to lose more energy, so they sink deeper into the cluster's center. Thus, as the cluster ages, its core becomes more dense.

Not long ago, astronomers thought most globular clusters would continue evolving in this way until a massive black hole formed at the cluster's center. But theorists now believe that the core collapse eventually stops and then reverses itself.

The extremely dense core seen in ground-based images of M15 led astronomers to conclude that this cluster was the most likely to be experiencing core collapse now. The Hubble observations, however, show clearly that M15 is well past the collapse phase.

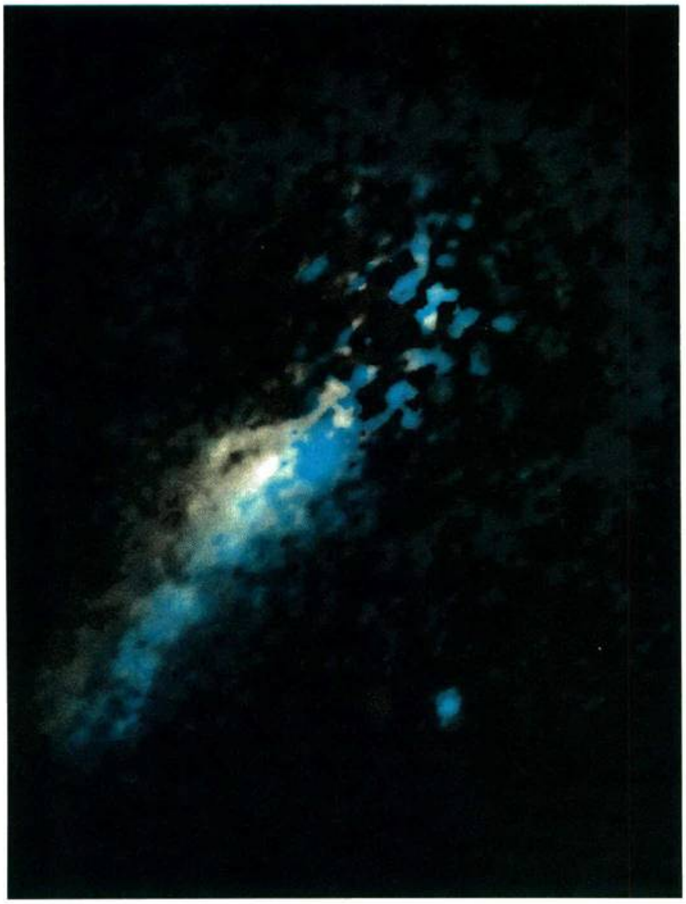
In both ground-based and HST images, the light from the central regions of M15 is dominated by a relatively small number of red giant stars. The Planetary Camera images were so sharp, however, that researchers could subtract out the bright stars by computer and leave just the faint stars that trace the core's underlying structure. When that was done (opposite page, bottom), the core turned out to be surprisingly smooth and, though still extremely dense, at least a factor of 100 *less* dense than it would appear at maximum collapse.

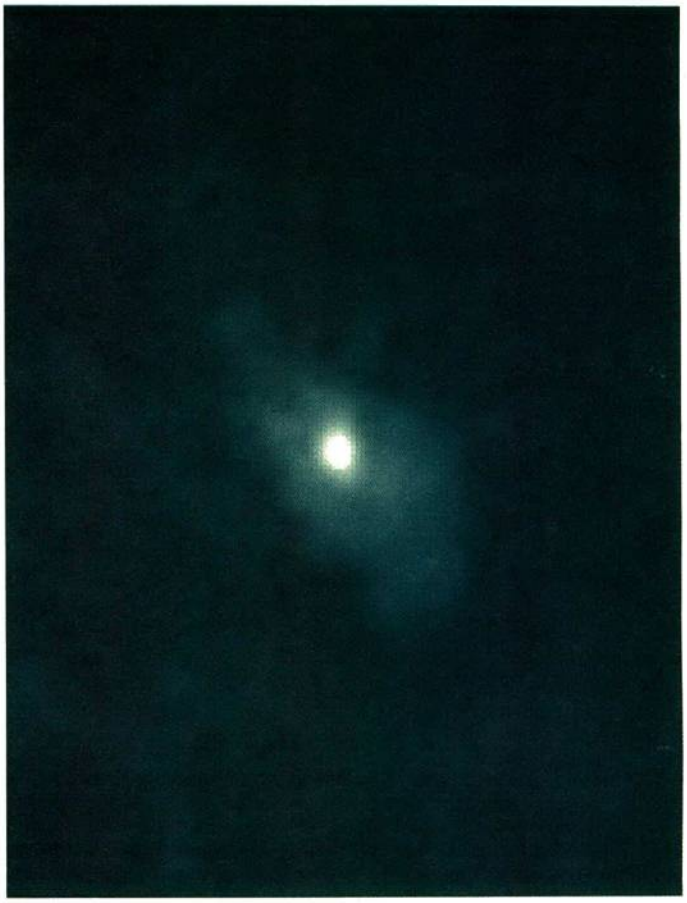
The smooth background also tends to rule out a massive black hole at the cluster's center. If there really were a black hole of roughly 1,000 solar masses in the core, its intense gravitational field would draw stars to it and the HST images would show a much higher central concentration.

Peering into Galaxies

While HST's cameras revealed that the core of M15 likely does not harbor a black hole, they have elucidated the environs of suspected black holes at the centers of active galaxies. Using the Faint Object Camera, astronomers zeroed in on an optical jet shooting out from the core of one of these active galaxies, the radio source 3C 66B in the constellation Andromeda. The image (see page 48) shows that the jet has a bizarre braided structure unlike any ever seen in an optical jet. The jet also displays filaments, bright knots, kinks, and other complex and intriguing structures.

Astronomers suspect that the jet in 3C 66B, like those in other active galaxies, is powered by a supermassive





A BRAIDED OPTICAL JET shoots out of the galaxy 3C 66B (left). NASA/ESA image. The nuclear region of the Seyfert galaxy M77 has an unexpectedly asymmetric shape (right). NASA image.

black hole in the galaxy's core. The black hole's intense gravity sucks in any stars, gas, and dust in its vicinity, creating a swirling accretion disk of superhot matter. The accretion disk, in turn, generates powerful magnetic fields aligned with the black hole's axis of rotation. As high-speed electrons spiral out along these lines of magnetic force, they radiate light at a wide range of wavelengths.

Astronomers are puzzled by the long length and intricate structure of 3C 66B's optical jet. Most optical jets extend a few hundred light-years, but the one in 3C 66B is about 10,000 light-years long. Either the radiating electrons must be re-energized as they shoot out along the jet or they must travel in regions where the magnetic field strength is much lower than normal. The jet's braided appearance indicates that the latter scenario is more likely. The kinks *in the jet*, on the other hand, suggest that the energy source in the galaxy's core fluctuates in intensity.

HST's First Spectra

The imaging cameras on Hubble got most of the observing time during the first six months of the mission. But in the last six months the two spectrographs — the Goddard High Resolution Spectrograph (GHRS) and the Faint Object Spectrograph (FOS) — have been put through their paces as well. Early results show they are working superbly and display HST's ability to return spectra of unprecedented quality.

The GHRS takes spectra in the ultraviolet region of the electromagnetic spectrum. Earth's atmosphere absorbs this high-energy radiation, so ground-based telescopes are useless for ultraviolet astronomy. And though previous satellites, most notably the International Ultraviolet Explorer (IUE), have taken ultraviolet spectra, HST's spectrographs are much more sensitive.

One of the GHRS's first targets was the bright star Aldebaran. The spectrum, even though taken in the medium-resolution mode, shows far more detail than any seen before (see page 47). The GHRS found more than 20 new spectral features in just a 50-angstrom band in the ultraviolet, nearly doubling the number of features seen in an IUE spectrum of the same object.

In its highest resolution mode, the GHRS gives information about the motions of gas in Aldebaran's chromosphere. (This is the area of the star's atmosphere where most of the ultraviolet radiation comes from. It lies just above the star's visible surface.) A detailed analysis of the spectral lines of singly ionized carbon and cobalt shows that the average speed of the turbulent gas in the chromosphere is 24 kilometers per second (14 miles per second). However, the detailed shape of the spectral lines suggests that this velocity varies with height in the chromosphere.

HST's optical problems have not affected the spectrographs as much as they have the imaging cameras. The chief complication is that exposure times must be longer than originally planned. Even so, when compared to the spectrograph on IUE, the HST instruments show significantly more detail at exposure times only a few percent as long.

As Hubble enters its second year in orbit, astronomers look forward to a slew of discoveries. Most of the instruments have now been assessed, and scientific observations will start in earnest. No one knows for sure what the next image or spectrum will show. To find out, we'll all just have to stay tuned. □

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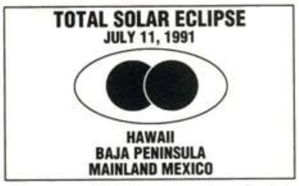

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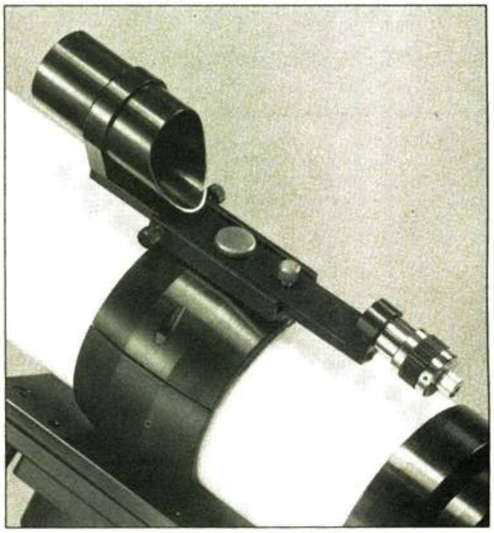

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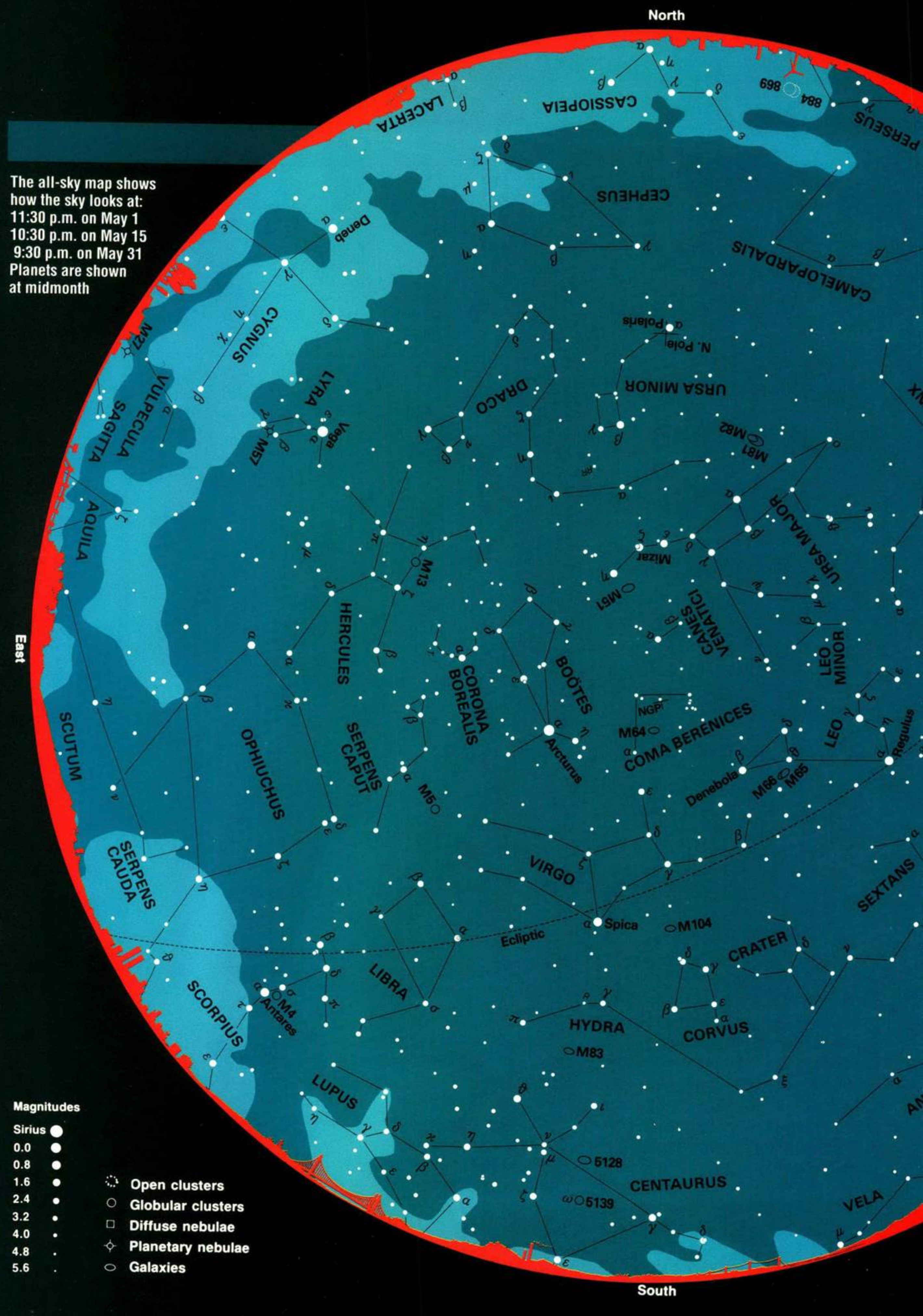
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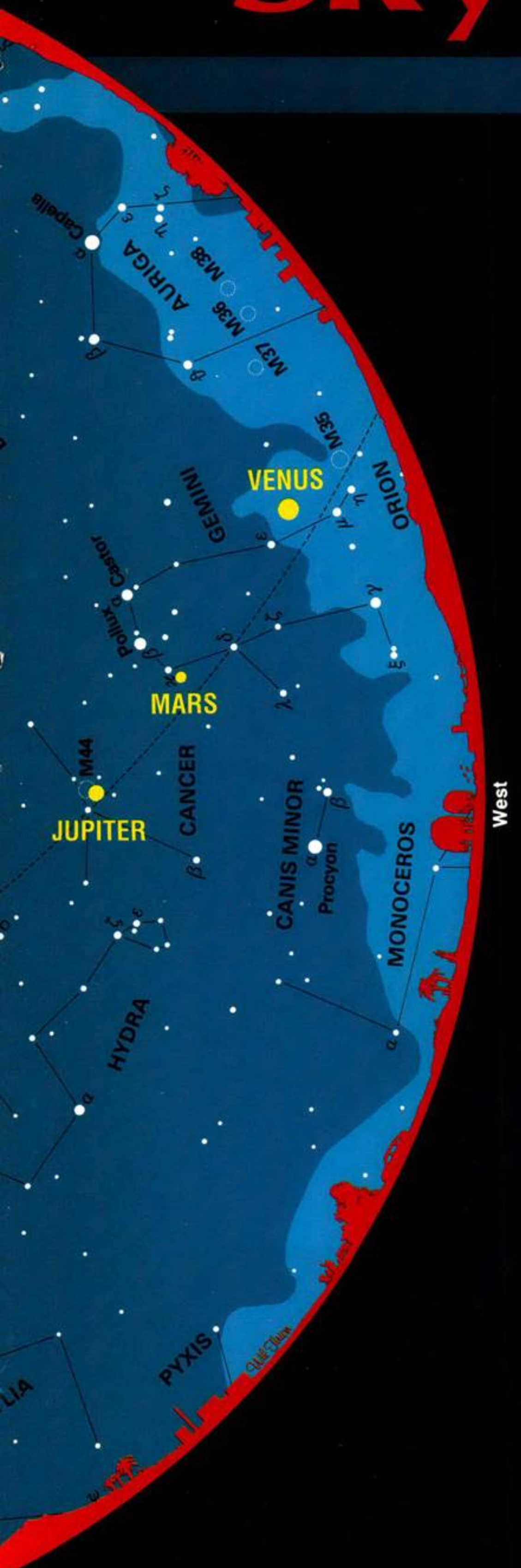


THREE PLANETS IN THE EVENING

Venus, Mars, and Jupiter string out in a line across the western evening sky during May, pulling closer to one another as the month progresses. The waxing crescent Moon passes through the scene on May 16, 17, and 18, when it overtakes each planet in turn.

SPOT A VERY YOUNG MOON

Few people have seen the Moon when it is less than 24 hours old, but observers in North America have a good chance of doing just that on the evening of May 14. To spot the very slender crescent Moon, pick an observing site with a clear view down to the west-northwest horizon and scan that area with binoculars beginning no later than 30 minutes after sunset.

GASPRA REACHES OPPOSITION

When Galileo flies by asteroid 951 Gaspra later this year, the spacecraft is expected to return the first-ever detailed images of an asteroid. You can get a pre-flyby look at this faint object, albeit from a much greater distance, by focusing your telescope on it around the time of opposition on May 22.

Calendar of Events

3 The Moon is at apogee (251,676 miles from Earth), 10:38 a.m. EDT

5 Eta Aquarid meteor shower peaks

6 The Moon passes 1.8° north of Saturn, 3 a.m. EDT
Last Quarter Moon is at 8:46 p.m. EDT

9 Pluto is at opposition

12 Mercury is at greatest western elongation (26°)

14 New Moon is at 12:36 a.m. EDT

15 The Moon is at perigee (224,083 miles from Earth), 12:42 p.m. EDT

16 Mars passes 5° south of Pollux, 1 a.m. EDT

17 The Moon passes 1.6° south of Venus, 3 a.m. EDT
Saturn is stationary

18 The Moon passes 2° south of Mars, 6 a.m. EDT

19 The Moon passes 2° south of Jupiter, 3 a.m. EDT

20 First Quarter Moon is at 3:46 p.m. EDT

22 Asteroid Gaspra is at opposition

28 Full Moon is at 7:37 a.m. EDT

30 Venus passes 4° south of Pollux, 9 p.m. EDT
The Moon is at apogee (252,197 miles from Earth), 10:53 p.m. EDT

by Deborah Byrd

A TRIO OF EVENING PLANETS

As May begins, three planets lie in a line leading up from the west-northwestern horizon after sunset. From the horizon up, they are Venus, Mars, and Jupiter. You can follow these planets throughout the month as they move in front of the star background, drawing nearer to one other. In June they will appear spectacularly close together.

Two of the planets are brighter than any star. Venus is the brightest at magnitude –4.1, Jupiter is next at magnitude –2.0, and Mars, which is nearly 200 times fainter than Venus, shines at magnitude 1.5. Despite the many bright stars in the western twilight sky now, you can't mistake Mars if you draw an imaginary line between Venus and Jupiter and look for the brightest object on that line.

Throughout the month, the planets creep closer together, while the "fixed" stars behind them sink slowly but steadily toward the Sun. When the month begins, Venus, Mars, and Jupiter lie within about 40° of each other. They end the month within about 15°.

Be sure to watch at mid-month, when the young Moon sweeps through this part of the sky. It moves just far enough each day to pass each planet in turn. The Moon is near Venus on the evening of May 16, near Mars the following evening, and near Jupiter the evening after that.

SUBTLE SHADES OF ORANGE frame a slender crescent Moon in Jeff Myers' photo from January 11, 1986. You may be able to see an even slimmer crescent Moon low in the west-northwest shortly after the Sun sets on May 14.

SEEKING A YOUNG MOON

The planets in the western sky can guide your eye to a fragile young Moon on the evening of May 14. It's not often that you will see the Moon when it is less than a day from being new, or most directly between the Sun and Earth. The Moon is new at 12:36 a.m. EDT on May 14 and thus it might be visible as a ghostly crescent shortly after sunset the following evening.

An imaginary line drawn through Jupiter, Mars, and Venus and extended toward the horizon points toward the young Moon. The Moon lies just above the west-northwestern horizon. Look for it no later than about half an hour after sunset on May 14. Use binoculars to sweep near the horizon if you have to, but then put the binoculars aside and try to glimpse the crescent with your naked eye.

A LEGACY OF COMET HALLEY

The most famous comet of all, Comet Halley, returned to the inner solar system in 1985-86. Halley is now speeding along more than a billion miles from the Sun, but its legacy appears in our sky each May.

Meteors in the Eta Aquarid shower, which peaks this year on the morning of May 5, originated in Comet Halley. Meteors in annual showers start out as bits of debris left behind by comets as they orbit the Sun. Halley's orbit is thought to have intersected that of Earth thousands of years ago. Now the comet's orbit has shifted, but meteors still streak across our sky whenever Earth crosses the old orbit. The meteors take their name not from Comet Halley but from the fact that they radiate from a point near the star Eta in the constellation Aquarius the Water Carrier.

Unfortunately, this year's display of Eta Aquarids may be more fun to think about than to watch. The Moon is in a waning gibbous phase when the shower is at its maximum on May 5. It rises around midnight and sheds its unwanted glare on any meteors streaking across your predawn sky. With the fainter meteors all but washed out, you shouldn't expect to see more than about 10 meteors per hour on the morning of the 5th.

MAY'S PLANETS

Venus is the brightest object in the evening twilight sky. It has spent the spring months climbing higher in the west after sunset, while moving closer to Earth in its smaller orbit around the Sun. Now Venus is very brilliant and as high in the sky as it will be for this evening apparition. It sets about three-and-a-half hours after sunset.

Despite appearing highest in the sky in May, Venus doesn't reach its maximum separation from the Sun (called its "greatest elongation" by astronomers) until June. The planet is higher in the sky now because the ecliptic — or path of the Sun, Moon, and planets — makes a steeper angle relative to the western horizon after sunset.

Mars can be seen above Venus in the western twilight sky, lying among the stars of Gemini for most of May. Both planets pass Gemini's brightest stars, Castor and Pollux, during the course of the month. The Red Planet passes 5° south of Pollux on the night of May 15/16, while Venus passes 4° south of Pollux on the night of May 30/31.

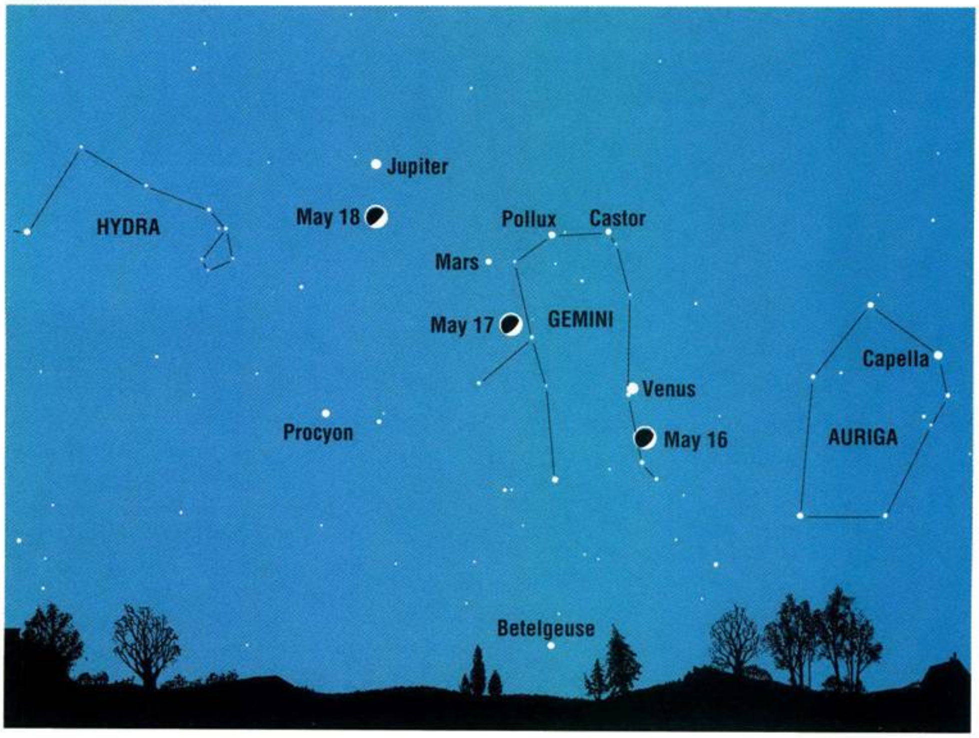
Jupiter lies high in the western twilight sky this month, shining brightly at magnitude –2.0. It outshines all the stars, including the sky's brightest star, Sirius, which is well below and to the left of Jupiter when May begins. Still, Jupiter is significantly fainter than Venus.

The giant planet appears against the stellar backdrop of Cancer. It is still near the Beehive star cluster on the dome of the sky, but the cluster is becoming more difficult to see as it gets closer to the Sun's glare.

Saturn rises shortly after midnight and is at its highest in the south around daybreak. It is a 0.6-magnitude object among the comparatively faint stars of Capricornus. It will continue to rise earlier and get brighter as the weeks pass, in preparation for its opposition in late July.

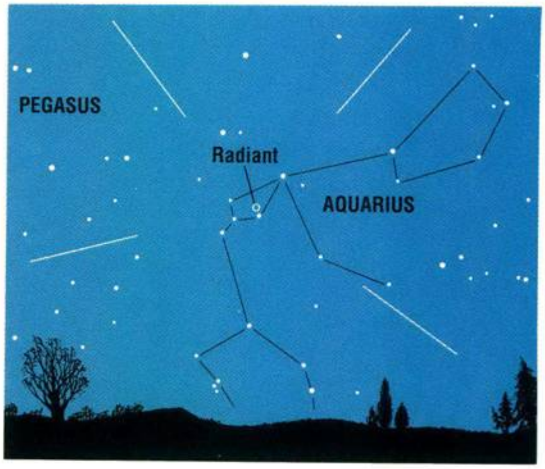
This month an event takes place that heralds Saturn's coming opposition. On May 17, the planet is stationary, poised motionless in front of Capricornus' stars. Afterward, the planet appears to move westward in front of the stellar background. The outer planets undergo this illusion of westward motion around the time of opposition, as Earth prepares to pass between them and the Sun.

Mercury rises before the Sun at mid-month, but it's not easy to see. It never gets far enough above the eastern horizon before dawn to be seen easily. Greatest elongation comes on May 12, when Mercury lies 26° west of the rising Sun. It is also 9° south of the waning crescent Moon that same morning. Careful observers who sweep near the



WATCH THE WESTERN SKY on the evenings of May 16, 17, and 18, as the waxing crescent Moon glides past Venus, Mars, and Jupiter in succession.

KEEN-EYED OBSERVERS can expect to see about 10 Eta Aquarid meteors per hour before dawn on May 5. Unfortunately the Moon, which is approaching Last Quarter phase, will wash out the shower's fainter meteors.



horizon with binoculars may spot the pair. Otherwise, you will have to wait until July, when Mercury has a pretty good evening apparition, to see the innermost planet.

THE STARRY SKY

On a warm spring evening, travel into the country and look above to see one of the sky's most fascinating constellations, Coma Berenices, or Berenice's Hair. Coma Berenices is a delicate grouping of mostly 4th- and 5th-magnitude stars representing the hair of an Egyptian queen.

Look south of the crook in the Big Dipper's handle. Be sure you are looking on a moonless night from a location far from city lights. And use your binoculars, which show this constellation to good advantage.

Coma Berenices, an exquisite open star cluster, differs from most constellations because many of its stars are related. That is, member stars are thought to have been born from a single cloud of gas and dust in space. These stars are still loosely bound by gravity.

The cluster wasn't classified as a separate constellation until the great observer Tycho Brahe did so in 1602. Until then, it was regarded as part of Leo the Lion, marking a tuft of hair at the end of the Lion's tail. The constellation is named for a queen of Egypt, Berenice II, who lived from 246 to 221 B.C. When the tragedy of war took her husband away to a distant battlefield, Berenice vowed to sacrifice her "amber tresses" to the goddess of beauty in exchange for his safe return.

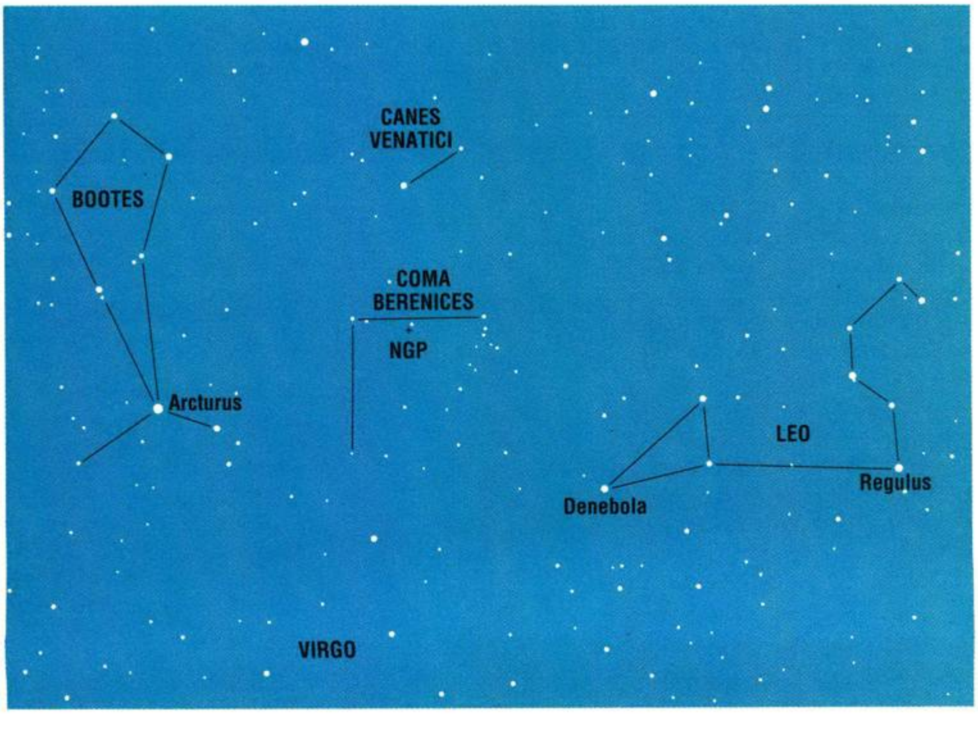
The king did return, so true to her promise, Berenice, with great ceremony, presented her hair to the altar of Venus. Then the hair mysteriously vanished, angering Berenice and her king. To soothe the royal tempers, the court astronomer is said to have shown the king and queen a faint cluster of stars in the night sky. This, he said, was Berenice's hair, now enshrined in the heavens by the gods.

The constellation Coma Berenices is significant for its location in our sky. It marks the direction to the north pole of the Milky Way Galaxy. Like Earth, the Galaxy rotates around a central axis. Most of its stars lie in a flat, pancakelike disk that is perpendicular to this axis. From our perspective, on May evenings the broad band of the Milky Way lies close to the horizon, while the north pole of the Galaxy lies overhead, in Coma Berenices.

When we gaze toward the north galactic pole, we are looking as far from the disk of the Galaxy as we can. Thus, by looking in this direction, we can see what lies beyond our Milky Way. Small telescopes show thousands of faint external galaxies in this region of the sky. Even a pair of low-power binoculars might reveal a fuzzy patch or two — perhaps another galaxy, or perhaps one of the great globular clusters of stars orbiting around the Galaxy's center. ☐

Deborah Byrd is the creator, writer, and producer of "Star Date," an independently syndicated daily radio series on commercial and public radio.

COMA BERENICES is a fairly faint constellation, but it is important because it marks the direction to the north galactic pole (NGP). You can find Coma overhead on May evenings, between the brighter constellations Leo and Bootes.



Through the Eyepiece by *Rick Shaffer*

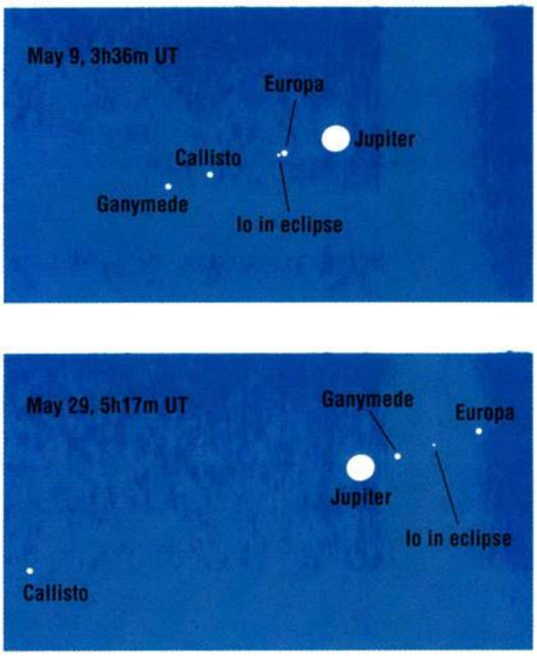
JUPITER IN THE SPOTLIGHT

Although it seems like Jupiter was at opposition only yesterday, it was actually opposite the Sun way back in January. Maybe it's the weather, which robbed us of many observing nights, that makes the time seem so short. Fortunately, observing conditions are usually better in the spring than in the winter. And with Jupiter still high in the evening sky during May, this should be an excellent month to focus on Jupiter.

Because Jupiter is so bright — it shines at magnitude –2.0 — you can start observing it as soon as the Sun sets. If you're lucky, you may even get a period of relatively steady seeing as the temperature gradient of Earth's atmosphere "flips" as we move from day to night. You should be able to locate Jupiter in the bright twilight sky by scanning with binoculars. Once you've found it, you can observe the giant planet until it sets around midnight.

As you look at Jupiter, you should see a wealth of detail on the planet's 36"-diameter disk. But you can improve the view by using a collection of colored filters. A light blue filter enhances the contrast between the belts and zones that girdle the planet, while a green filter makes the Great Red Spot appear darker relative to the other features.

ECLIPSES AND OCCULTATIONS among Jupiter's Galilean satellites offer more treats for North American observers during May.



THE DANCE OF THE GALILEAN MOONS

This month both the Sun and Earth continue to lie near the plane of Jupiter's equator, which is also the orbital plane of Jupiter's four Galilean satellites. This means that the number of mutual eclipses and occultations among the four satellites remains high. Eclipses outnumber occultations because the Sun is closer to the plane of Jupiter's equator than Earth is, passing through the plane on May 11.

The mutual events visible from North America this month are listed in the table below. However, there are a few events worthy of special attention. The most spectacular one occurs on the night of May 28/29, when Ganymede eclipses Io for observers in western North America. Over the course of just 11 minutes, beginning at 5h12m UT on the 29th (10:12 p.m. PDT on the 28th), Io fades from its normal brightness to near invisibility and returns to normal again.

Although the 98-percent light loss of the May 28/29 event won't be beat this month, there are several other events to keep your eye on. Observers in eastern North America can see Io fade by 88 percent when it is eclipsed by Ganymede on May 21/22 (at 2h11m UT on the 22nd, 10:11 p.m. EDT on the 21st) and by 78 percent when it is eclipsed by Callisto on May 8/9 (3h30m UT on the 9th, 11:30 p.m. EDT on the 8th).

JUPITER AND THE BEEHIVE

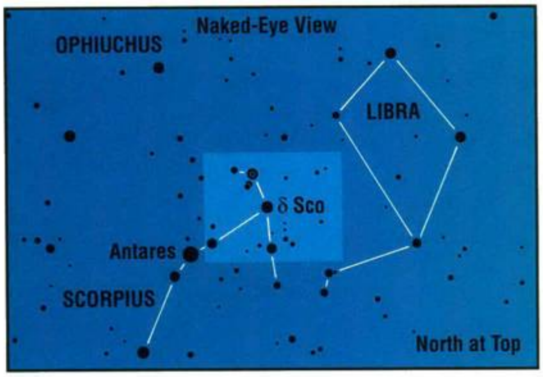
During the third week of May, Jupiter and its mini-swarm of bees invade the Beehive — the

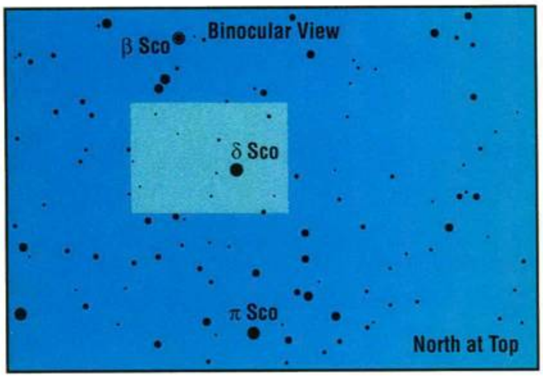
MUTUAL EVENTS OF THE GALILEAN SATELLITES

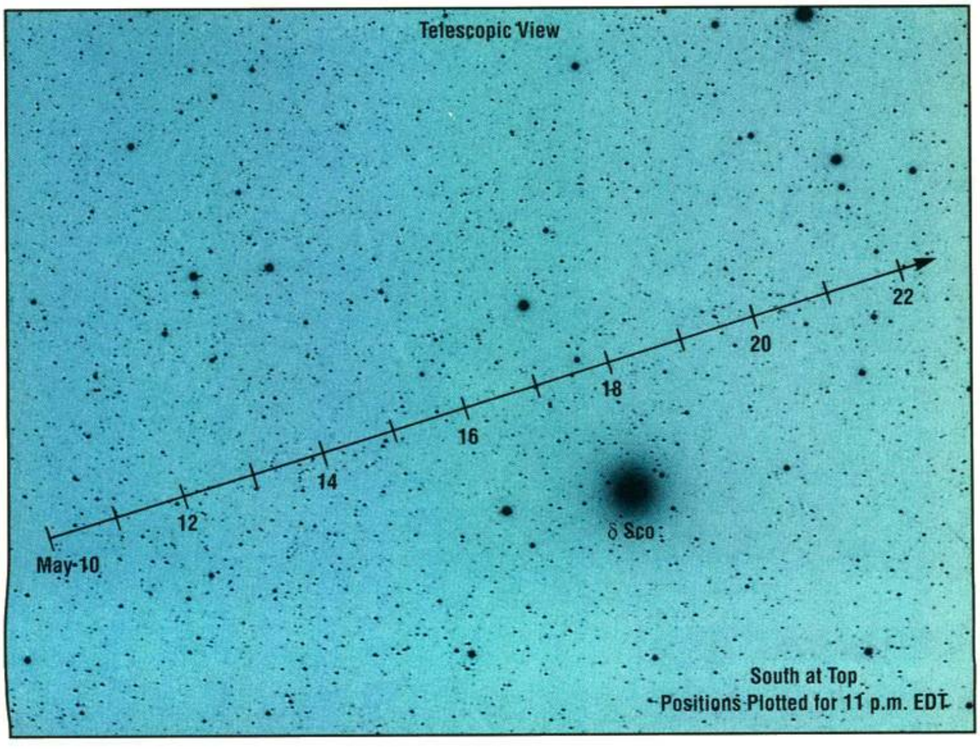
Date	Begin Time	End Time	Event	Type of Event	Light Loss	Distance
May 2	1h40m	1h42m	Europa Occults Io	Partial	1%	4
May 2	3h35m	3h38m	Europa Eclipses Io	Partial	4%	3
May 8	1h16m	1h32m	Callisto Eclipses Io	Partial	47%	6
May 9	3h30m	3h42m	Callisto Eclipses Io	Annular	78%	4
May 9	3h57m	4h00m	Europa Occults Io	Partial	2%	4
May 9	5h50m	5h53m	Europa Eclipses Io	Partial	1%	3
May 10	4h31m	4h55m	Callisto Eclipses Ganymede	Annular	66%	14
May 14	1h39m	1h44m	Io Eclipses Europa	Partial	75%	2
May 16	6h16m	6h18m	Europa Occults Io	Partial	4%	4
May 17	6h10m	6h19m	Io Eclipses Callisto	Partial	36%	7
May 21	3h55m	4h00m	Io Eclipses Europa	Partial	61%	3
May 22	2h11m	2h20m	Ganymede Eclipses Io	Partial	88%	5
May 26	4h06m	4h12m	Io Eclipses Ganymede	Partial	29%	4
May 28	6h11m	6h16m	Io Eclipses Europa	Partial	49%	3
May 29	5h12m	5h23m	Ganymede Eclipses Io	Partial	98%	6

Begin Time: Universal time at beginning of event. (Subtract 4 hours to convert to EDT, 5 hours for CDT, 6 hours for MDT, and 7 hours for PDT.) **End Time:** Universal time at end of event. **Event:** The nature of the event and the satellites involved. **Type of Event:** Whether the event is partial, total, or annular. **Light Loss:** For eclipses — the percent of light lost by the eclipsed satellite at midevent; For occultations — the percent of light lost from the combined light of both satellites at midevent. **Distance:** The apparent distance of the satellite from Jupiter's center in Jovian equatorial radii.

ASTEROID 951 GASPRA will be the first asteroid seen up close by humans when the Galileo spacecraft flies past it in October. But you can spot this exceedingly faint object in your telescope this month as it comes to opposition.







open cluster M44 in the constellation Cancer. You can observe this event with as little as a pair of binoculars, or with a telescope at low power. If your telescope is much larger than 6 inches in diameter, the finder might give you a better view because the cluster is about a degree across and Jupiter lies about half a degree from it.

Jupiter is closest to the Beehive on the nights of May 19 and 20 and, coincidentally, the 5-day-old Moon passes just south of Jupiter on the 19th. Although the Moon won't seem all that bright to the naked eye, it will tend to wash out the Beehive in your telescope. Try to position your telescope so the Moon is behind a telephone pole or some similar object. You can use the same trick if you plan to photograph the event.

As you watch Jupiter pass just south of the Beehive, you might contemplate the distances and sizes involved. The Moon is 3,480 kilometers in diameter and just 1.25 light-seconds away. Jupiter is 143,000 kilometers in diameter and 47 light-minutes away. The Beehive, on the other hand, is about 9 light-years across and a bit over 500 light-years distant. So as you view this scene, you're looking back in time as little as the time between blinks of your eye, to the length of time many people commute to work, to 25 human generations!

SATURN AND ITS SATELLITES

Saturn is now well up in the sky on May mornings. Although the white spot of last fall seems to have faded away during winter here on Earth, Saturn still bears watching because the one predictable aspect of the atmospheres of gas giants is that they are unpredictable.

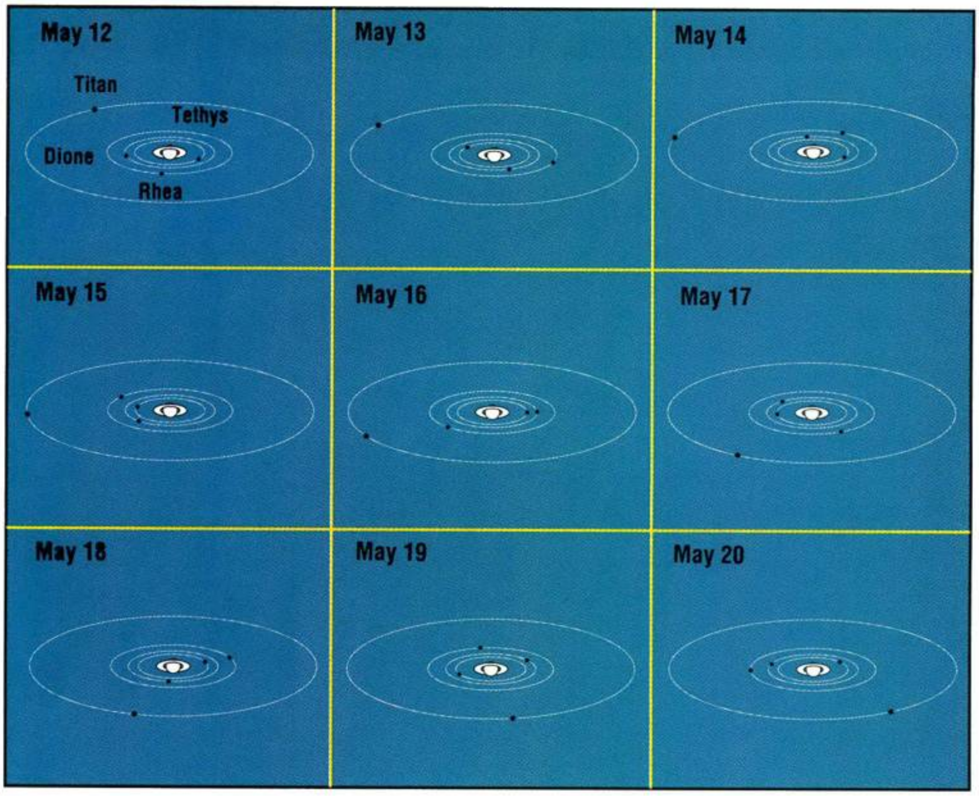
If you haven't had a look at Saturn for a while, you'll immediately notice that the rings don't appear as open as they did last fall. In fact, they reach their narrowest opening of 1991, 18.9°, in mid-May. The rings will continue to close in upcoming years until they appear edge-on in 1995.

To ensure that you have enough objects to observe this month, we've shown the positions of Saturn's brightest moons at the top of the next page. With this, you'll be able to identify the four brightest satellites of Saturn: Tethys, Dione, Rhea, and Titan, in order of their distance from Saturn. Their magnitudes are 10.2, 10.4, 9.7, and 8.3, respectively, so you'll have little difficulty seeing them in a 4-inch or larger telescope. In an even larger scope, you might be able to detect the distinctly reddish tint of Titan.

PLANETS IN THE EYEPIECE

Mercury is at its greatest separation from the Sun (26° west) on May 12. Unfortunately, this apparition is a poor one for Northern Hemisphere observers because the ecliptic makes such a shallow angle relative to the eastern horizon on May mornings. At greatest elongation, the innermost planet shines at magnitude 0.5 and displays an 8.1"-diameter, 41-percent-lit disk.

Venus is now fairly high in



SATURN'S FOUR BRIGHTEST MOONS are easy to spot when you know where to look. The satellites' positions are shown at 4 a.m. EDT (3 a.m. CDT, 2 a.m. MDT, and 1 a.m. PDT). South is at top to match the view in an inverting telescope.

the west during evening twilight. Its apparent size and phase change noticeably over the month, the former growing from 15.9" to 20.4" and the latter shrinking from 70-percent lit to 57-percent lit. However, next month Venus' telescopic appearance really starts to change. As a bonus, there will be interesting planetary conjunctions galore. Stay tuned.

The best time to observe Mars is early in the month. That's when it appears largest in the eyepiece and thus you're most likely to see some of the planet's subtle surface markings. Unfortunately, there isn't a lot to see right now because Mars is far across the solar system from Earth and appears only 5" in diameter.

Pluto reaches opposition on May 9/10 and New Moon occurs on May 14, so the middle of the month is the best time to look for the most distant planet. See "Pluto Meets the Serpent" in the April issue for details on how to locate this planet. Because you're trying to find a 13.7-magnitude object, you need to locate Pluto's field precisely and make a careful drawing of the field on successive nights. The "star" that moves from one night to the next is Pluto.

You should try to look for Pluto near midnight, when it is highest in the south. Also remember to select an observing site with good seeing, because poor seeing can cut a magnitude off your limiting magnitude. (In very good seeing, Pluto has been detected with a telescope as small as 6 inches in diameter. However, an 8- or 10-inch scope gives you a much better shot at finding the elusive planet.)

ASTEROIDS IN THE EYEPIECE

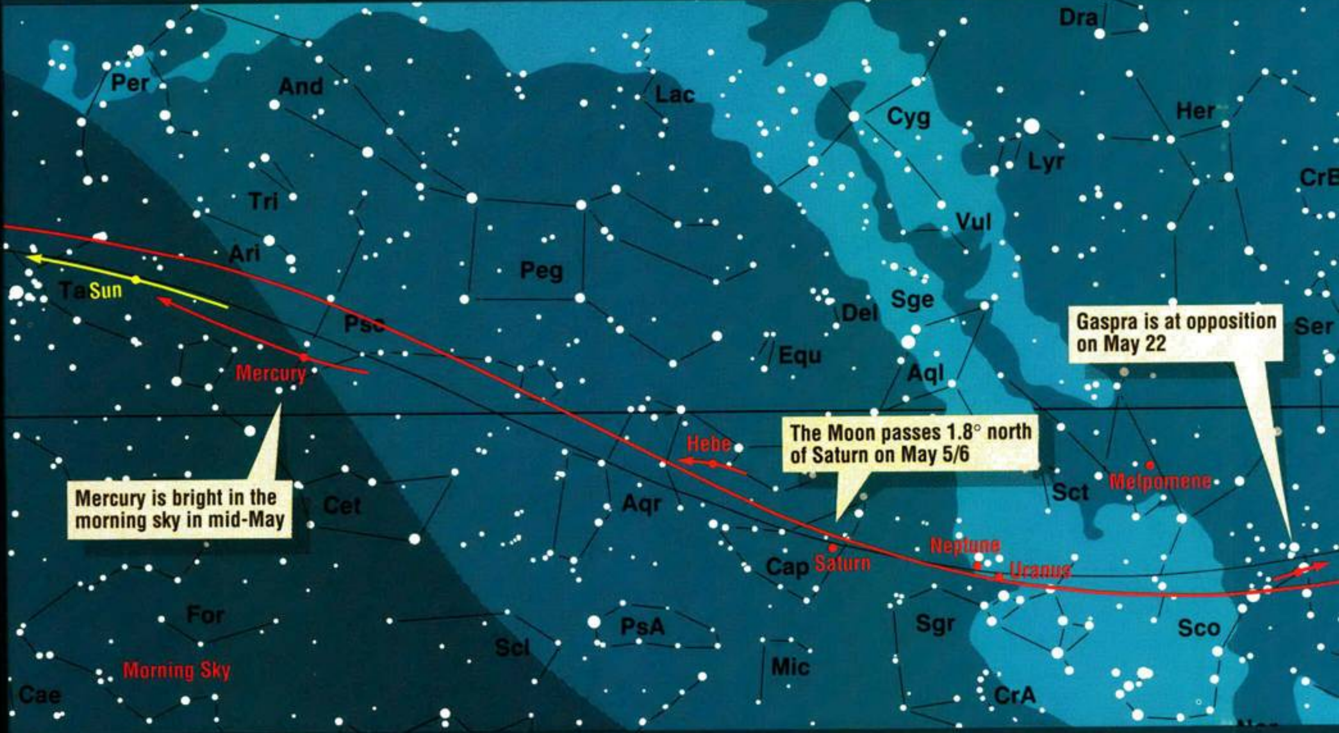
I've never directed you to an asteroid much fainter than 10th magnitude before because there is usually something else more interesting going on. However, asteroid 951 Gaspra is an exception, even though its opposition magnitude is between 14 and 15. The reason? Gaspra — a 16- to 20-kilometer-wide piece of primordial solar system debris that was named after a resort built for astronomers in the Crimea — will have a visitor from Earth later this year.

The Galileo spacecraft, which is on a long journey to the planet Jupiter, will speed by Gaspra on October 29. Galileo will study Gaspra with an array of sophisticated instruments and is expected to return the first-ever closeup images of an asteroid. To find Gaspra, use the finder charts on the opposite page, along with the methods I described for locating Pluto. Gaspra's proximity to the bright star Delta (δ) Scorpii should make your hunting a bit easier. Good luck. ☐

Rick Shaffer is a technical group leader at the Jet Propulsion Laboratory in Pasadena, California. He leads the data management team on the Ulysses mission, which is on its way to Jupiter and ultimately the Sun.

JUPITER PASSES THE BEEHIVE star cluster in mid-May, the third and final meeting of these objects in the past year. Robert Provin and Brad Wallis captured this pair in 1978, the last time Jupiter was in the Beehive's vicinity.

The Solar System May 1991



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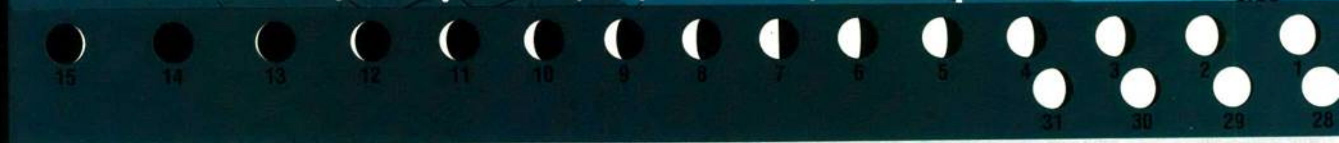
Saturn
Neptune
Uranus
For
PsA
Sgr
Sco
Scl
Mic
Morning Sky
Cae
CrA

Mercury is bright in the morning sky in mid-May

The Moon passes 1.8° north of Saturn on May 5/6

Gaspra is at opposition on May 22



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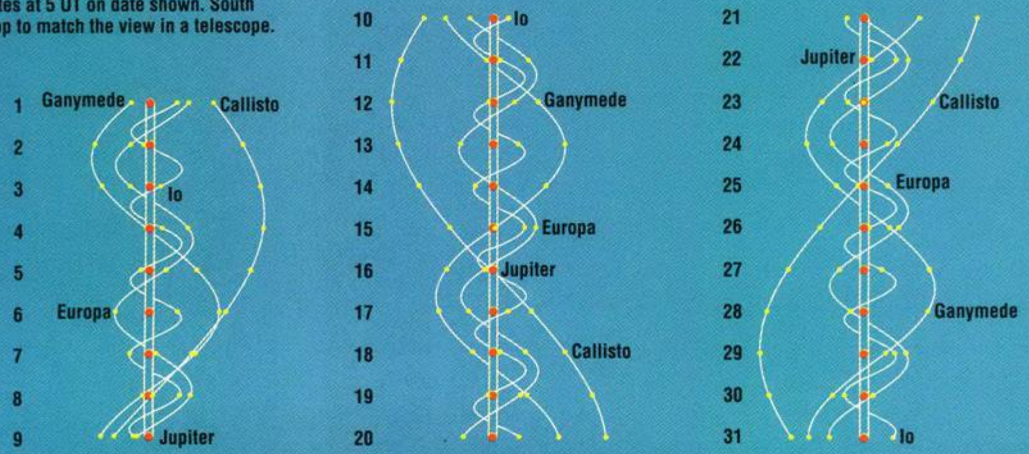
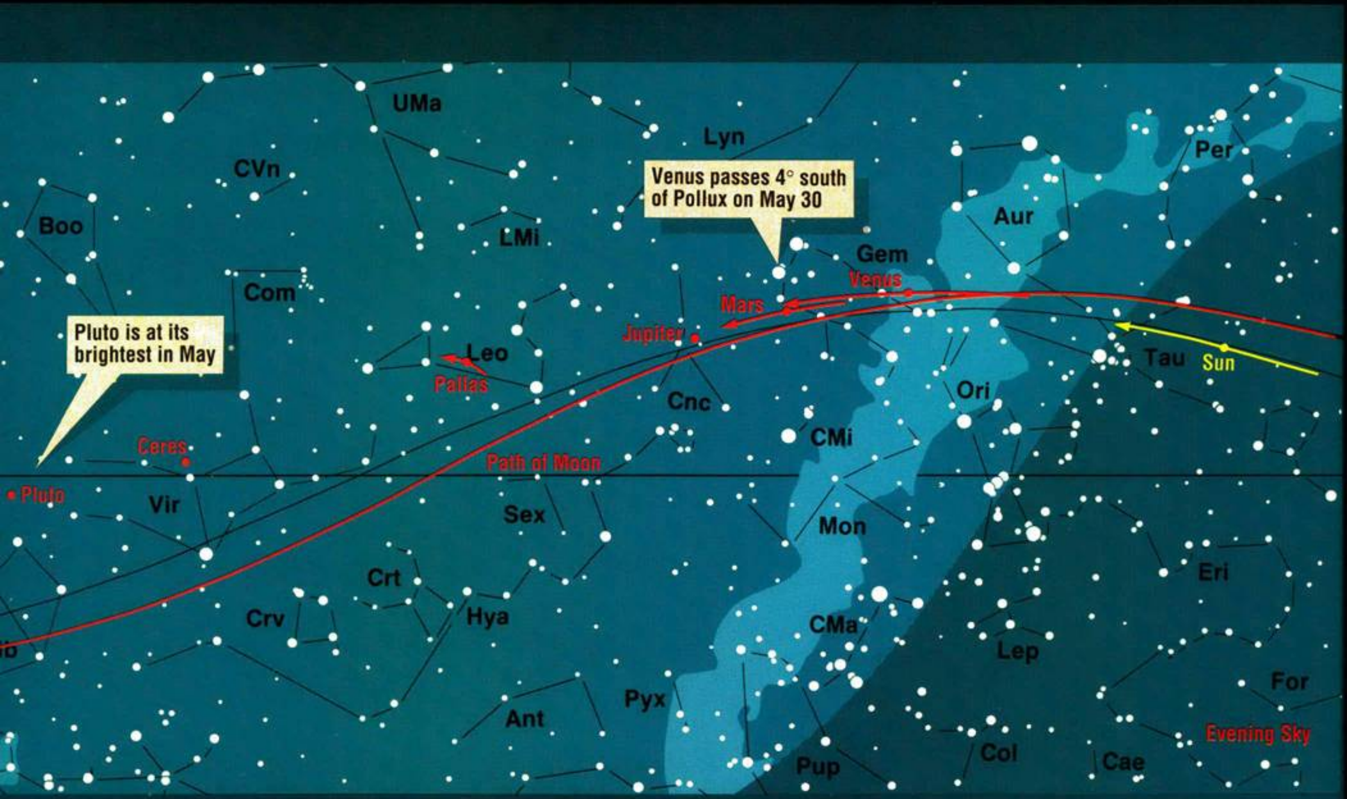
Planet	MERCURY	MERCURY	VENUS	MARS
Date	May 1	May 31	May 15	May 15
Magnitude	+1.5	−0.5	−4.1	+1.5
Angular Size	10.2″	5.9″	17.6″	4.9″
Illumination	21%	74%	64%	93%
Distance (AU) from Earth	0.660	1.138	0.946	1.927
Distance (AU) from Sun	0.466	0.368	0.719	1.663
Right Ascension (2000.0)	1h10.9m	3h15.2m	6h29.9m	7h42.3m
Declination (2000.0)	5°21′	16°04′	25°51′	22°58′

Jupiter's Moons

Dots display positions of Galilean satellites at 5 UT on date shown. South is at top to match the view in a telescope.




Venus passes 4° south of Pollux on May 30

Pluto is at its brightest in May

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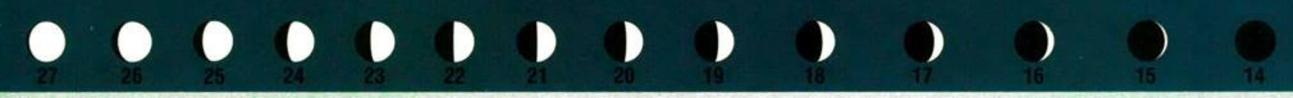
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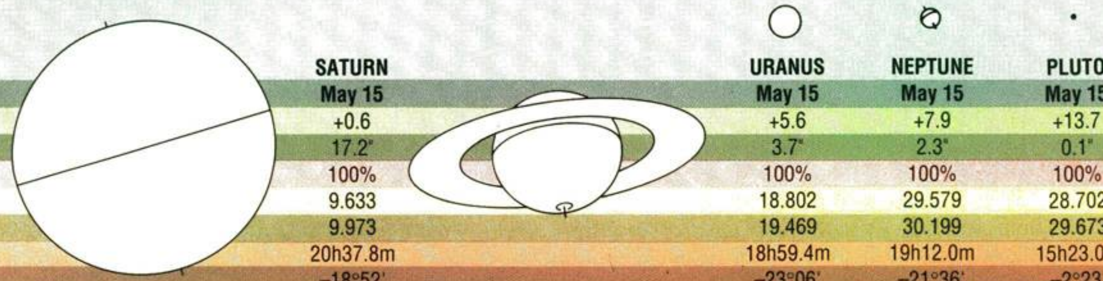
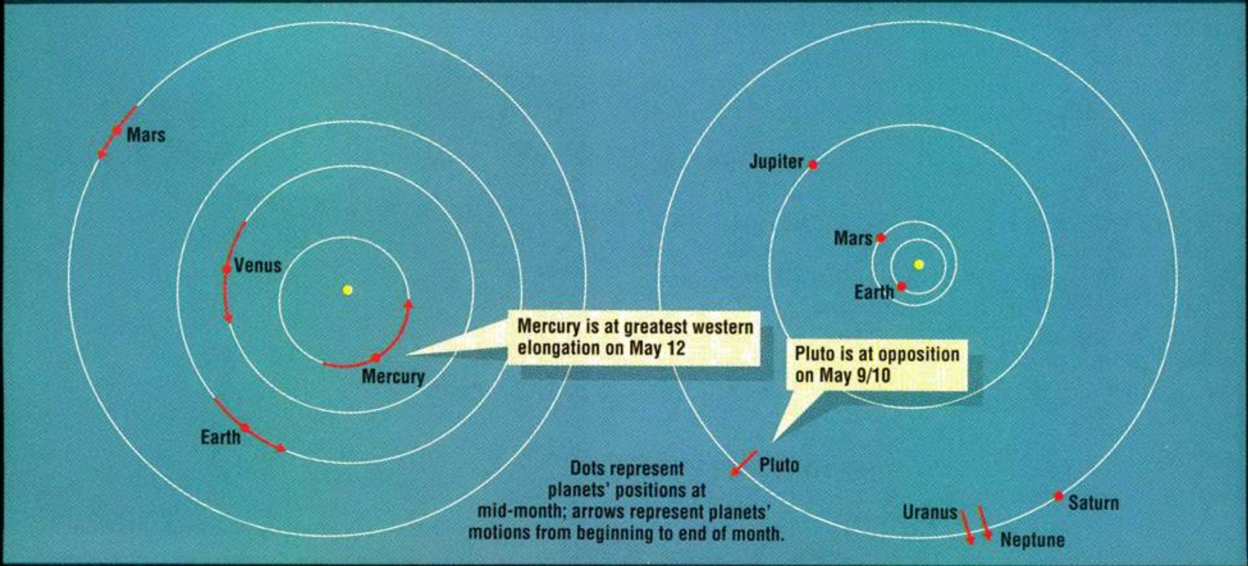


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
May 15	May 15	May 15	May 15	May 15
–2.0	+0.6	+5.6	+7.9	+13.7
35.6"	17.2"	3.7"	2.3"	0.1"
99%	100%	100%	100%	100%
5.534	9.633	18.802	29.579	28.702
5.325	9.973	19.469	30.199	29.673
8h37.2m	20h37.8m	18h59.4m	19h12.0m	15h23.0m
19°19'	–18°52'	–23°06'	–21°36'	–2°23'

The Planets in Their Orbits


Mercury is at greatest western elongation on May 12

Pluto is at opposition on May 9/10

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

Mars
Venus
Mercury
Earth
Jupiter
Mars
Earth
Pluto
Uranus
Neptune
Saturn

An Observer's Guide to Sunspots

Did you know that the Sun is the only star you can observe in detail and that observing it doesn't even require dark skies?

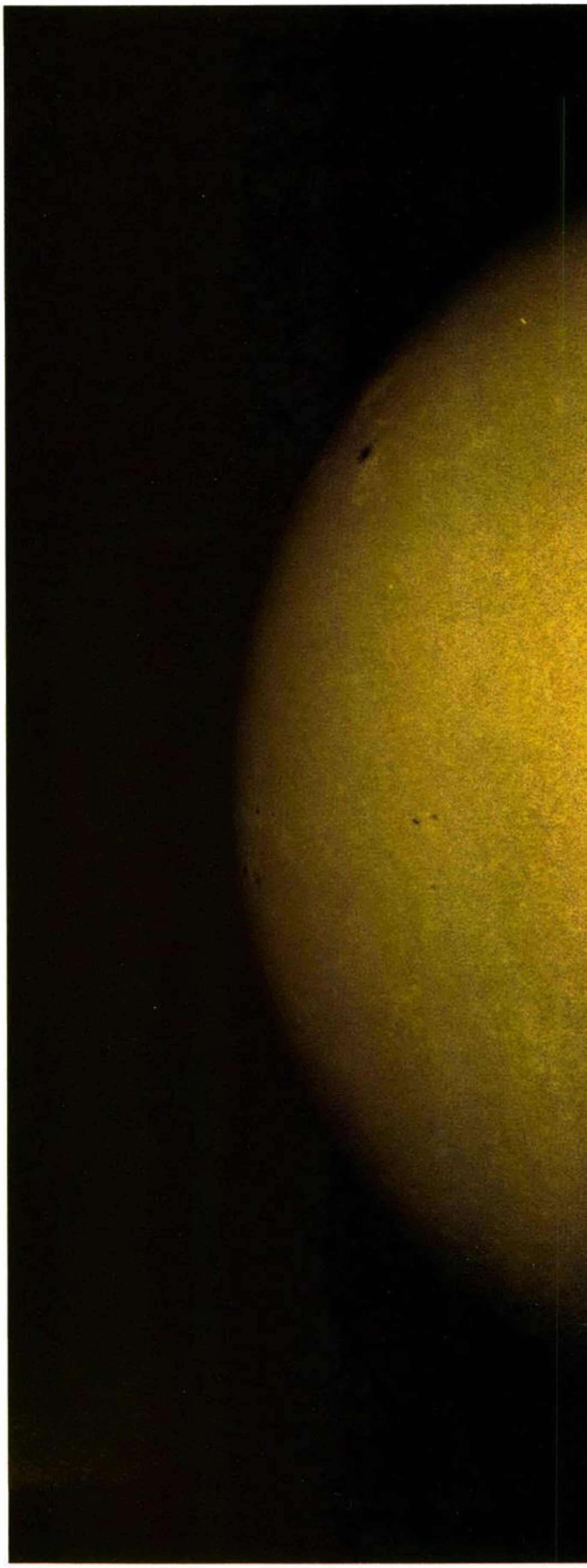
by Edmund Fortier

Every eleven years, as a new solar cycle builds toward maximum, astronomers witness a tremendous surge in sunspot activity. At such times these magnetic storms can, in the course of a few days or weeks, evolve into huge, finely detailed structures. In fact, it is not unusual for some sunspots to measure 25,000 miles or more across — large enough to be seen with the naked eye.

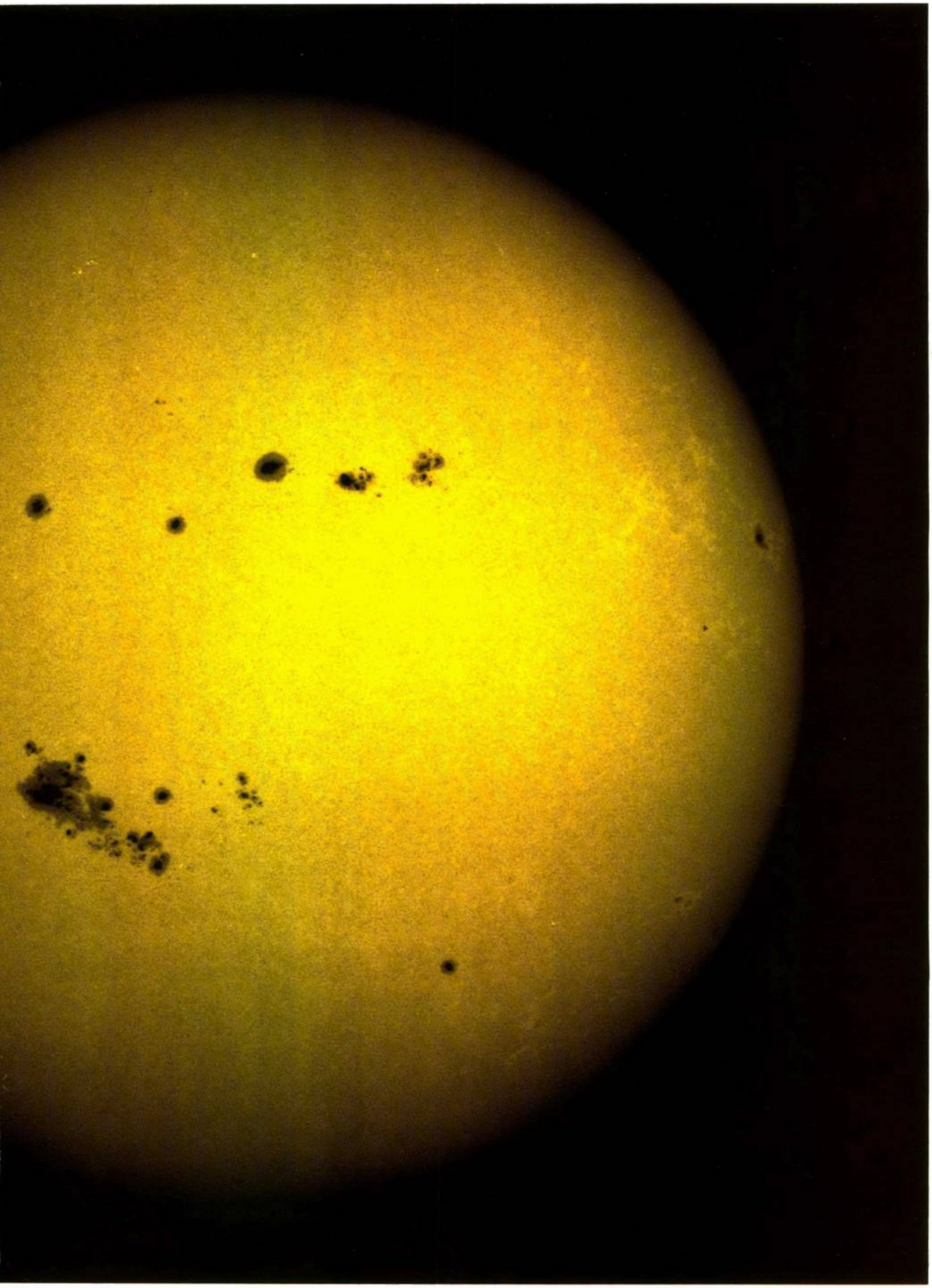
If you have been skywatching for less than ten years, you've never observed the Sun during its most active phase. The last peak in the solar cycle occurred in 1980. By mid-decade, activity had declined to minimum and sunspots had all but vanished from the surface of the Sun. Now the cycle is again at its eleven-year peak. Because the 1990 maximum was exceptionally active — and we are still in a period of high sunspot activity — this is an ideal time to take a close look at the evolution of a typical sunspot group and to consider the various features a careful observer can expect to see.

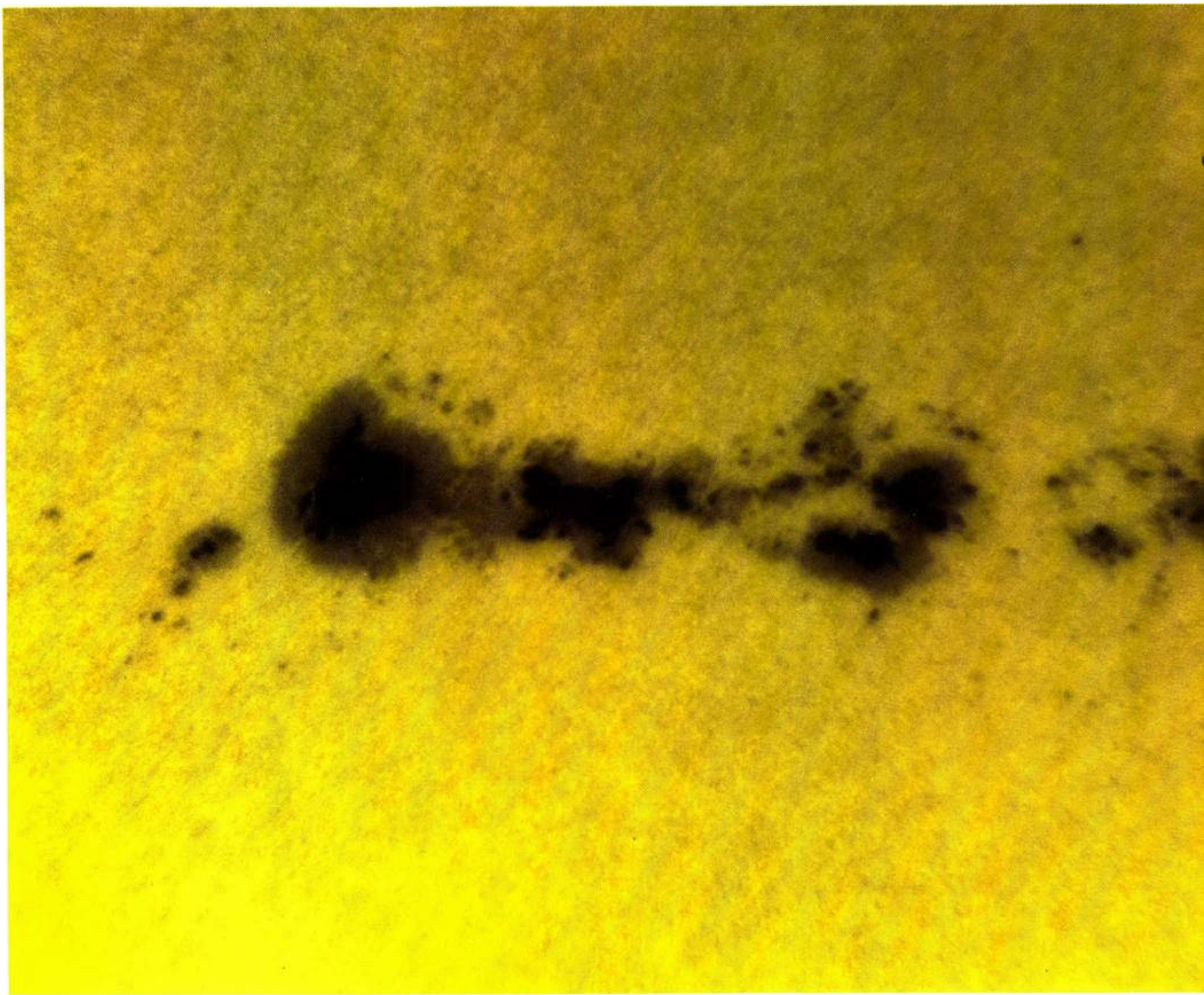
First, though, a word of caution: Never look at the Sun unless your telescope is properly fitted for solar observing. For sunspots, use a white-light filter. These filters, usually made from aluminum-coated Mylar film or Inconel-coated glass, attach to the front end of the telescope or can even be held in front of your entire face when looking at the Sun with the naked eye. Mylar filters produce a cool, bluish image of the Sun, which some observers find objectionable. Inconel filters, on the other hand, render the solar disk a warm and natural yellow-white, but they are more expensive. Whichever filter you choose, be sure that it fits securely and don't forget to cover your finderscope.

Now that you've heard the safety lecture, let's examine exactly what sunspots are, anyway. They are phenomena of the solar photosphere, the region of the Sun that emits most of the radiation we see. When you're next observing the Sun with a telescope, look closely at the center of the solar disk, and if the seeing is good, you'll detect a subtle "rice grain" texture called granulation. The photosphere is made up of several million individual granules. These tiny structures, which are actually a few hundred miles across,



SUNSPOTS, EASY AND FUN TO OBSERVE, offer changing patterns as the Sun rotates day by day. Photo by Lee C. Coombs.



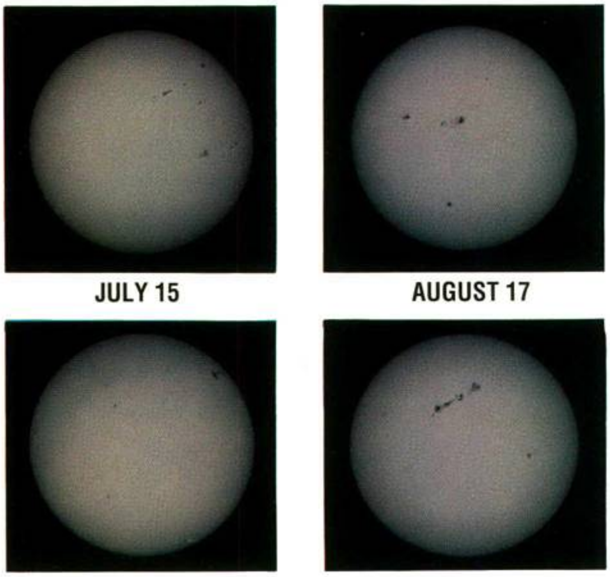


GIANT MAGNETIC STORMS, sunspots show dramatic details in small telescopes — multiple groupings, dark umbral centers, lighter penumbral areas, and whitish faculae.

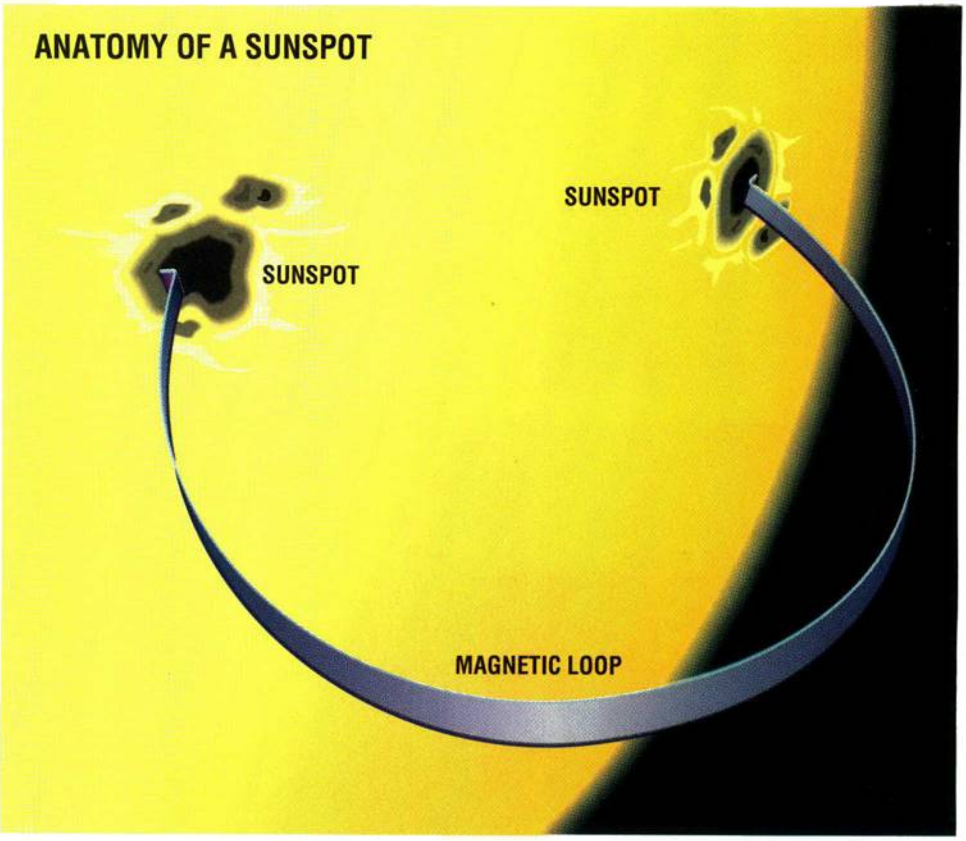
have an average lifetime of about ten minutes and are caused by convection, the rising and sinking of cells of hot gas. Granulation provides us with direct visual evidence of a convection cycle in the Sun.

You will quickly discover, however, that granules are not visible across the entire solar disk. The photosphere appears noticeably darker toward the edge of the Sun, and our view there is obscured. This phenomenon, known as limb darkening, occurs because light from the limb must pass obliquely through a greater thickness of photosphere, limiting our view to the cooler upper layers. In contrast, when we look at the center of the solar disk, we see deeper into the hotter and brighter layers of the Sun's atmosphere. Because of the contrast provided by the limb-darkening effect, the periphery of the Sun is the only place you can see the bright, mottled patches known as faculae. But faculae exist everywhere on the Sun, and astronomers think they are precursors to sunspots. These whitish streaks always precede the development of a sunspot, and they always survive its final dissolution.

How does a sunspot develop? All spots begin

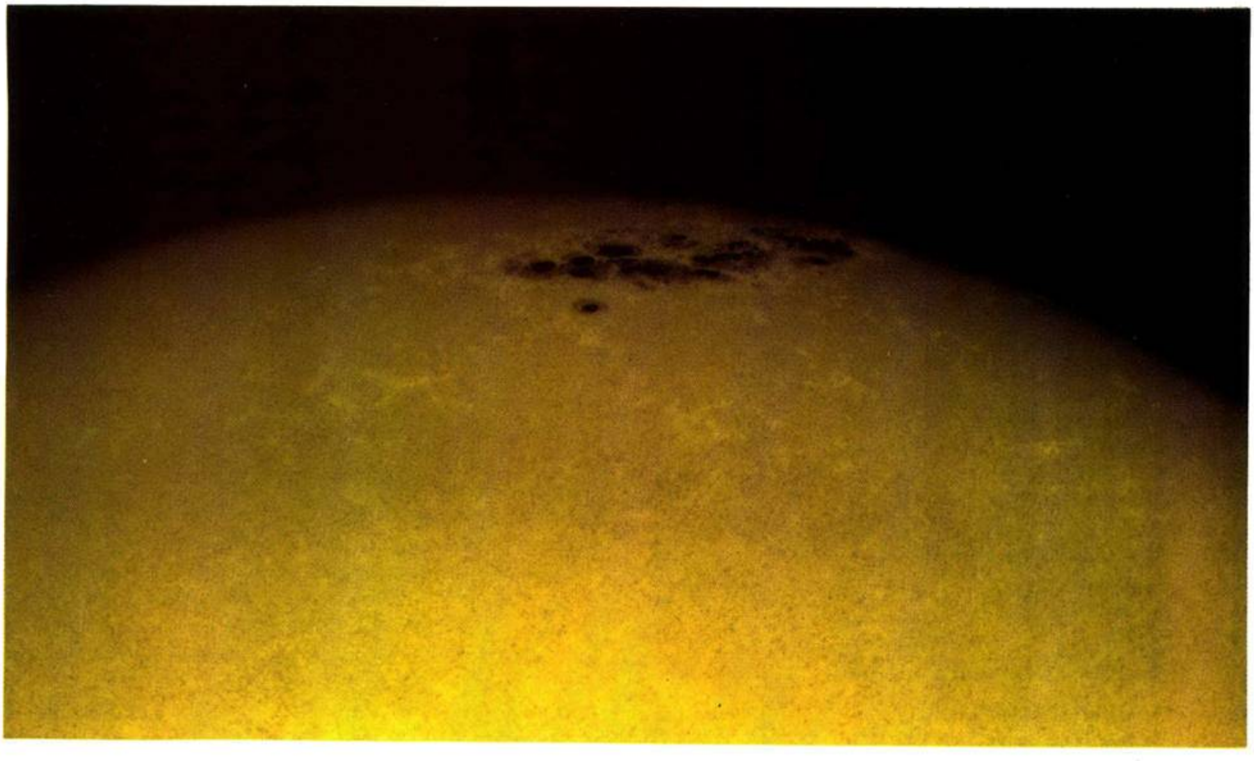


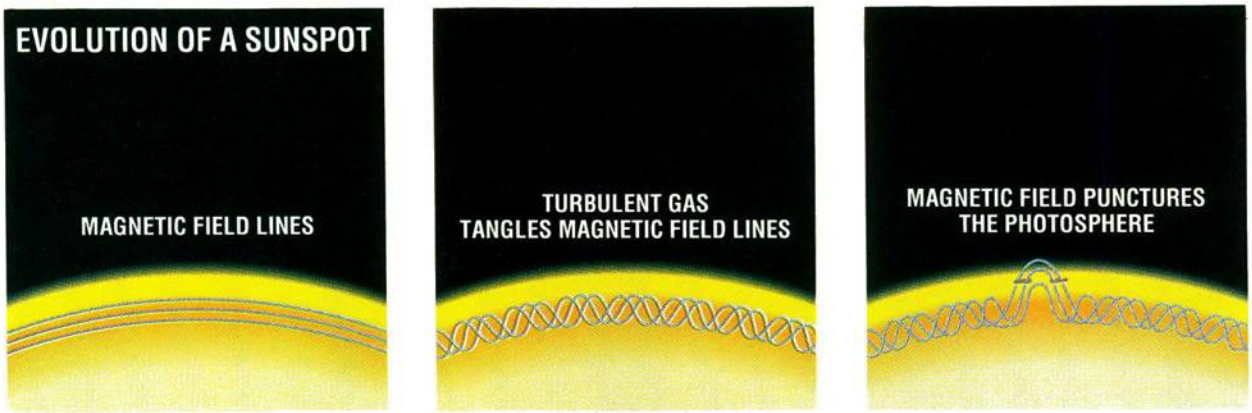
SIX WEEKS ON THE SUN shows the changing appearance of spots. Rick Dilsizian's sequence shows the Sun on July 15, August 17, August 30, and September 4, 1989.

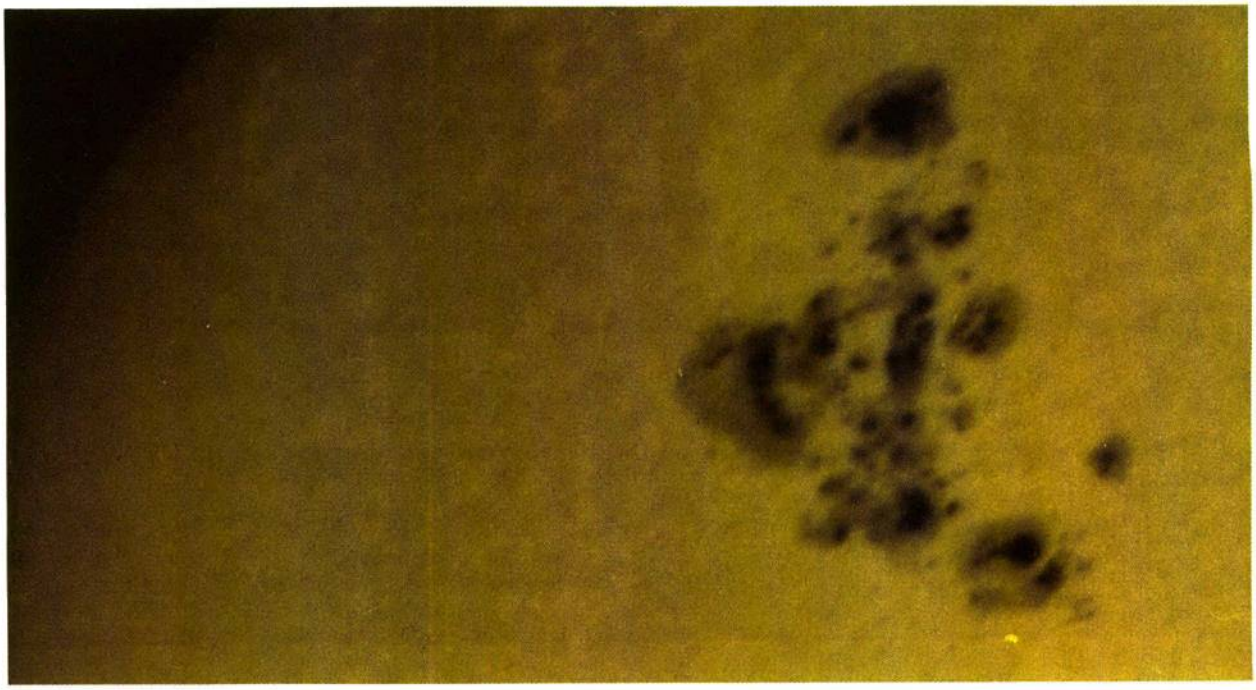

ANATOMY OF A SUNSPOT
SUNSPOT
SUNSPOT
MAGNETIC LOOP

SUNSPOTS ARE AREAS on the Sun's surface pierced by magnetic loops from inside the Sun.

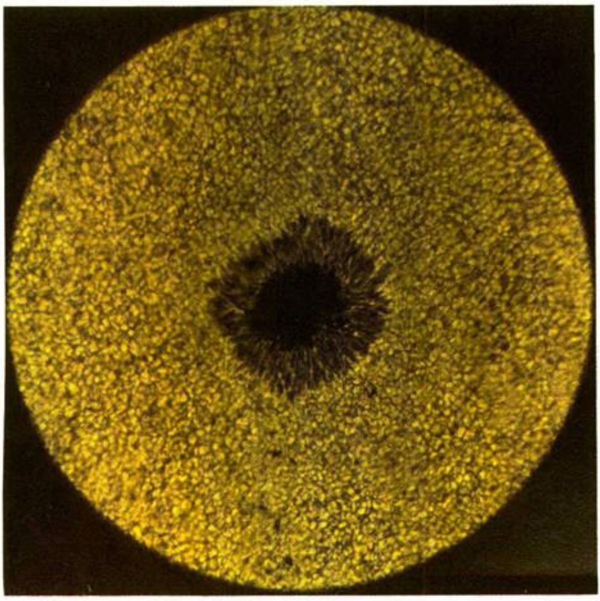
MAGNIFICENT DETAIL is visible in sunspot groups, like this one photographed by Gregory Terrance.




EVOLUTION OF A SUNSPOT
MAGNETIC FIELD LINES
TURBULENT GAS TANGLES MAGNETIC FIELD LINES
MAGNETIC FIELD PUNCTURES THE PHOTOSPHERE



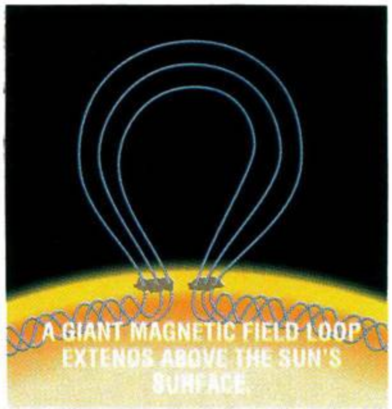
LARGE SUNSPOT GROUPS contain dark umbral centers, gray penumbral haloes, many large and small single and overlapping spots, and surrounding whitish plages. Photo by John S. Hicks.

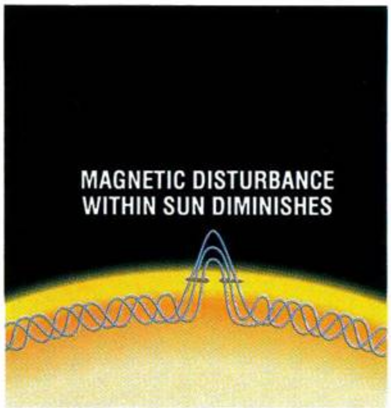


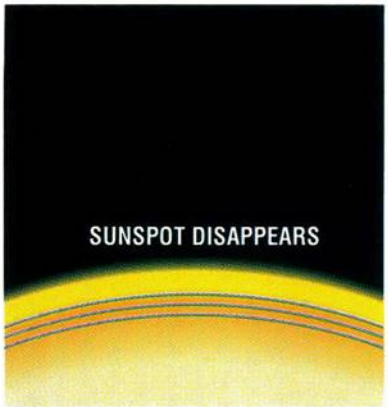
A SINGLE SUNSPOT seen close up shows magnificent detail. Sacramento Peak Observatory photo.

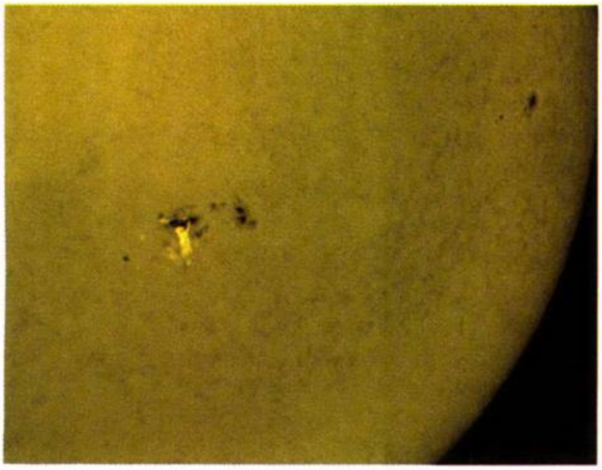
when a normally bright granule suddenly darkens, becoming a tiny, barely discernible spot called a pore. Most pores quickly disappear, but a few grow in size, developing a dark core called the umbra and the beginnings of a lighter, filamentary structure called the penumbra. Most spots dissolve at this point, but a few continue to grow, and within a day or two evolve into mature spots with large umbrae and full, symmetrical penumbrae. The temperature of such a sunspot falls to about 4000 K, some 2000 K cooler than the surrounding photosphere.

Although sunspots may develop as single entities, they can also develop in magnetically associated groups. These sunspot clusters are usually bipolar; that is, each contains sunspots of both polarities. In considering the evolution of these sunspot groups, it's important to keep two things in mind. First, a spot group may dissolve at almost any stage in its development,









A GIANT FLARE occasionally occurs in association with a sunspot. This hydrogen-alpha photo depicts an event that may also have been visible in white light. Courtesy NASA/NOAA Solar Observatory.

and only a handful pass through every phase of the cycle. Second, since the Sun rotates once every 27 days, two weeks is the longest you can keep a single group under constant surveillance.

Even the most complex sunspot group begins inauspiciously, with the sudden appearance of a few pores on the solar disk. Within a day the incipient group appears as two concentrations of umbral spots, elongated in a roughly east-west direction. One spot in each concentration usually develops more fully than the others.

During the first few days little of telescopic interest occurs. Around the second week of its existence, a sunspot group reaches maturity. The distance between the two main spots, which has been steadily increasing, reaches a maximum separation on about the tenth day. An exceptionally large group stretches across an appreciable fraction of the solar disk.

At first glance the umbra of a mature spot appears a uniform dark brown or black. Yet if conditions are favorable, careful examination with moderate to high magnifications may reveal the presence of minute bright spots. These features, called umbral dots, vary considerably in brightness and are not always visible.

More complex than a sunspot's umbra is its delicate, weblike penumbra. This structure consists of narrow, bright filaments on a darker background extending outward from the umbra. The umbra-penumbra border is usually well-defined but often irregular; look for points of umbral material invading the inner regions of the penumbra. Occasionally some of these projections will reach all the way across the penumbra to the photosphere.

Perhaps the greatest spectacle a solar observer can hope to witness is the eruption of a flare. In a matter of seconds an active solar region can release an astonishing amount of energy. Ordinarily such eruptions originate either in the solar chromosphere or the corona, and an H-alpha or other narrow-band filter is needed to see them. On rare occasions, however, the activity extends down to the level of the photosphere. When this happens the sudden release of energy can radiate across the entire electromagnetic spectrum, producing the rarest of all photospheric events, a white-light flare.

White-light flares are associated with complex, well-developed sunspot groups, particularly those containing several spots within a single penumbra. They appear as sudden, rapidly expanding areas of brightness, and are most often seen when projected against the dark background of a sunspot. A flare usually reaches peak brilliance in just a few minutes, after which it diminishes gradually in intensity.

The break up of a large sunspot group is a gradual process. First to disappear are the small spots scattered between the leader and the follower. Next the follower separates into several smaller spots, and these too gradually fade away. The leader, which has been growing progressively rounder and smaller, is the last to vanish. If the group is especially long-lived, the entire process, from birth to final dissolution, may take as long as two months.

With so much to see, it's no wonder solar observers are eagerly watching the high solar activity following the 1990 maximum. If you count yourself a serious stargazer but have never devoted much attention to our nearest stellar neighbor, now is the time to add it to your observing schedule. Remember, the Sun is not only the most dynamic object you can observe — it is also the only star in the universe you can study in detail with a backyard telescope. □

Edmund Fortier is an active observer living in North Scituate, Massachusetts. His last article was "Inside the Hyades" (February 1990).

Dodge and Burn: Image Processing on the Edge

Why settle for ho-hum drug store photos when a little darkroom craftsmanship can release the great images hidden in your negatives?

By Larry Myers

Every straight, unmanipulated print you make from an adequately exposed negative is really only a "souvenir" of a far-greater print that's waiting to be made from the same negative. Great astrophotos are not taken but created, because the real secret to them lies in what happens *after* you close the shutter.

Today's super-fast color negative films are wonderful, but yield their full potential only when you extract every last bit of pictorial value from them. Many amateur astrophotographers have learned to process and make prints in their own home darkrooms. If you are equipped to do your own printing and understand the basics, the time has come to take the next step and learn some darkroom magic.

Brights Too Bright; Darks Too Dark

When you take a photo of a galaxy or nebula, the film captures lots of details (such as filaments and spiral arms) having many levels of brightness. Depending on the object, one feature may be bright and visible to the naked eye while another may be virtually as dim as the night sky itself.

For example, take the Orion Nebula, an object whose features span a brightness range of at least 1,000-to-1, nearly all of which can be captured on film. Because the area around the Trapezium is bright, it is very dense on the negative. On the other hand, the nebula's outer edges are so faint that it can be hard to tell just where they leave off and the sky begins. In making a print, where density in the negative translates into brighter tones on the paper, you have to let through lots of light from the enlarger if you wish to reveal detail in the Trapezium region. But this heavy exposure will overexpose the outer nebula, darkening it in value and reducing its apparent size. Conversely, if you wish to show the outer nebula in the print, you turn to a short exposure. But this leaves the entire Trapezium region blankly white and devoid of detail.

It's true that some objects allow a single compromise exposure. But most often this simply preserves the worst of both extremes — an overdark outer edge and a center that's still washed out. The basic problem is that typical photo printing papers can at best reproduce shades of brightness over a range of only about 100-to-1, perhaps one-tenth of what the negative can record. This makes it necessary to compress the negative's full range of brightness in order to allow all the object's features to fall within the brightness scale of the paper. In practical terms, what's needed is to give different parts of the print differing amounts of exposure.

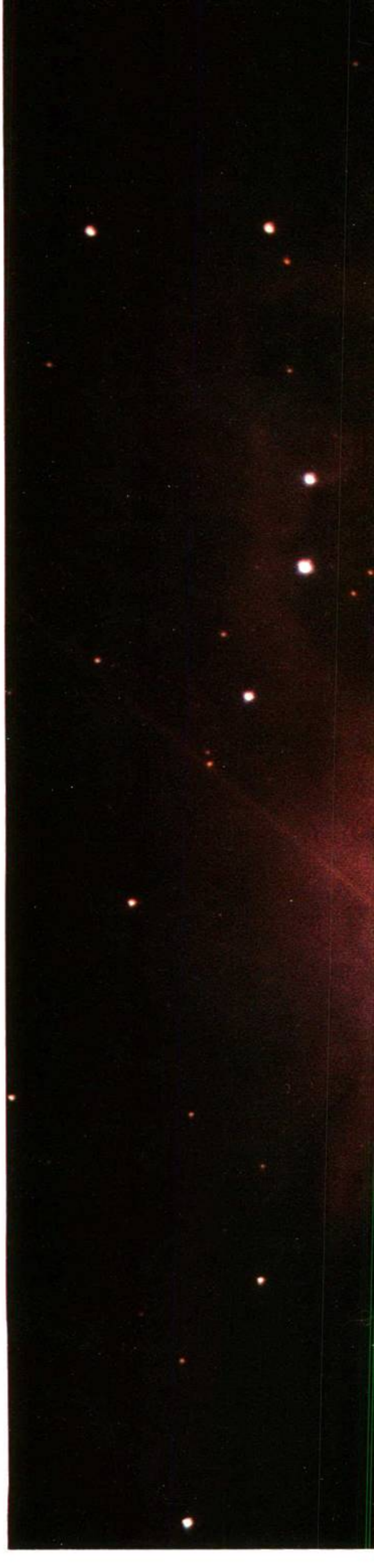
O.K., how is this done?

There are many ways, some quite sophisticated, but two of the most powerful darkroom techniques — dodging and burning — are easy to learn and apply. Dodging is a controlled underexposure of a specific area on the print. Burning is the opposite: careful overexposure of an area.

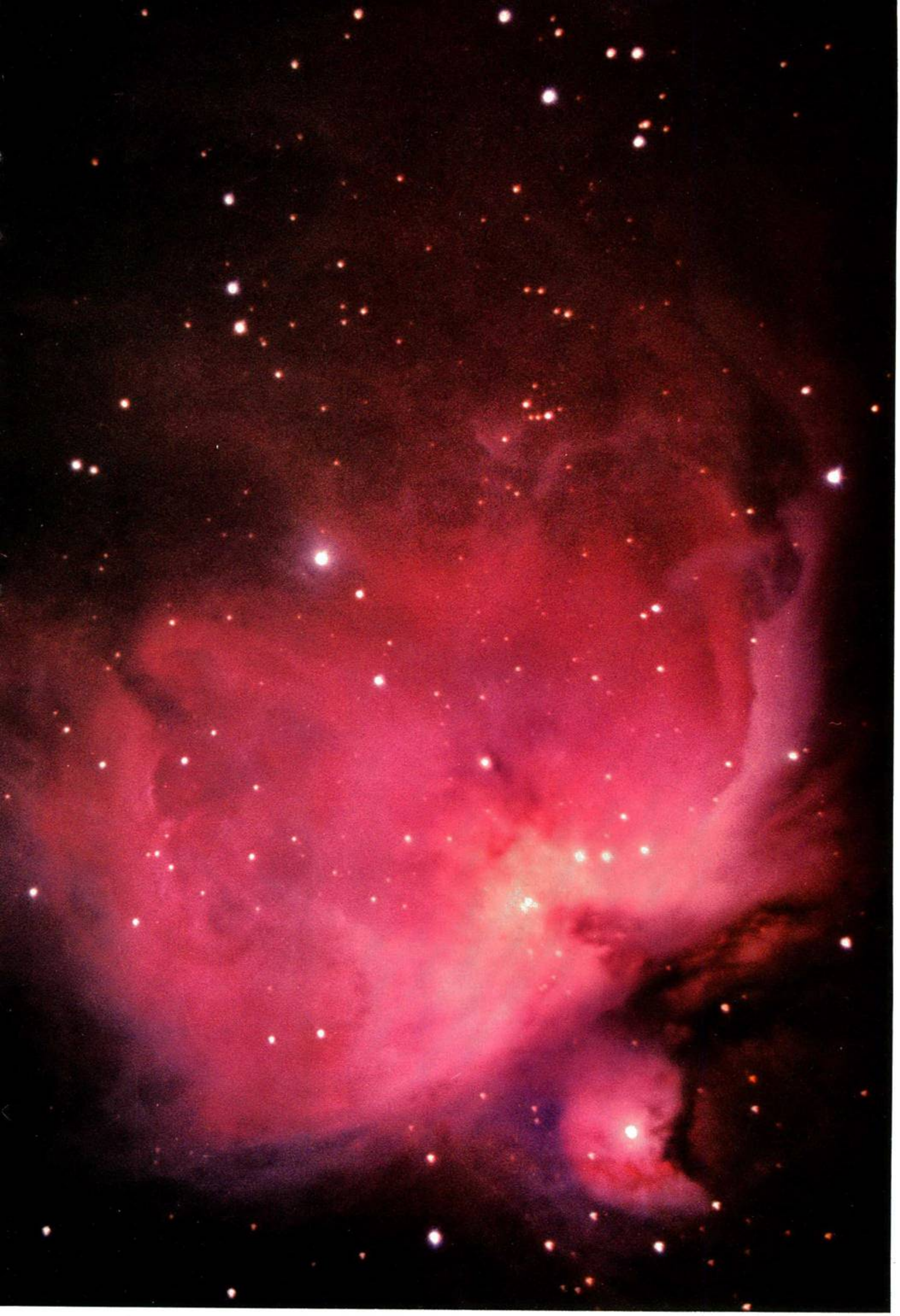
People sometimes wonder uneasily if these methods aren't compromising the integrity of the print — cheating, in other words. But think of it this way — you are not adding or subtracting anything from the original negative; every detail originally captured is still there. All you are doing is making each visible.

Tools of the Trade

The first step is making a couple of simple tools. A dodging tool is nothing more than a stiff wire (from a coat



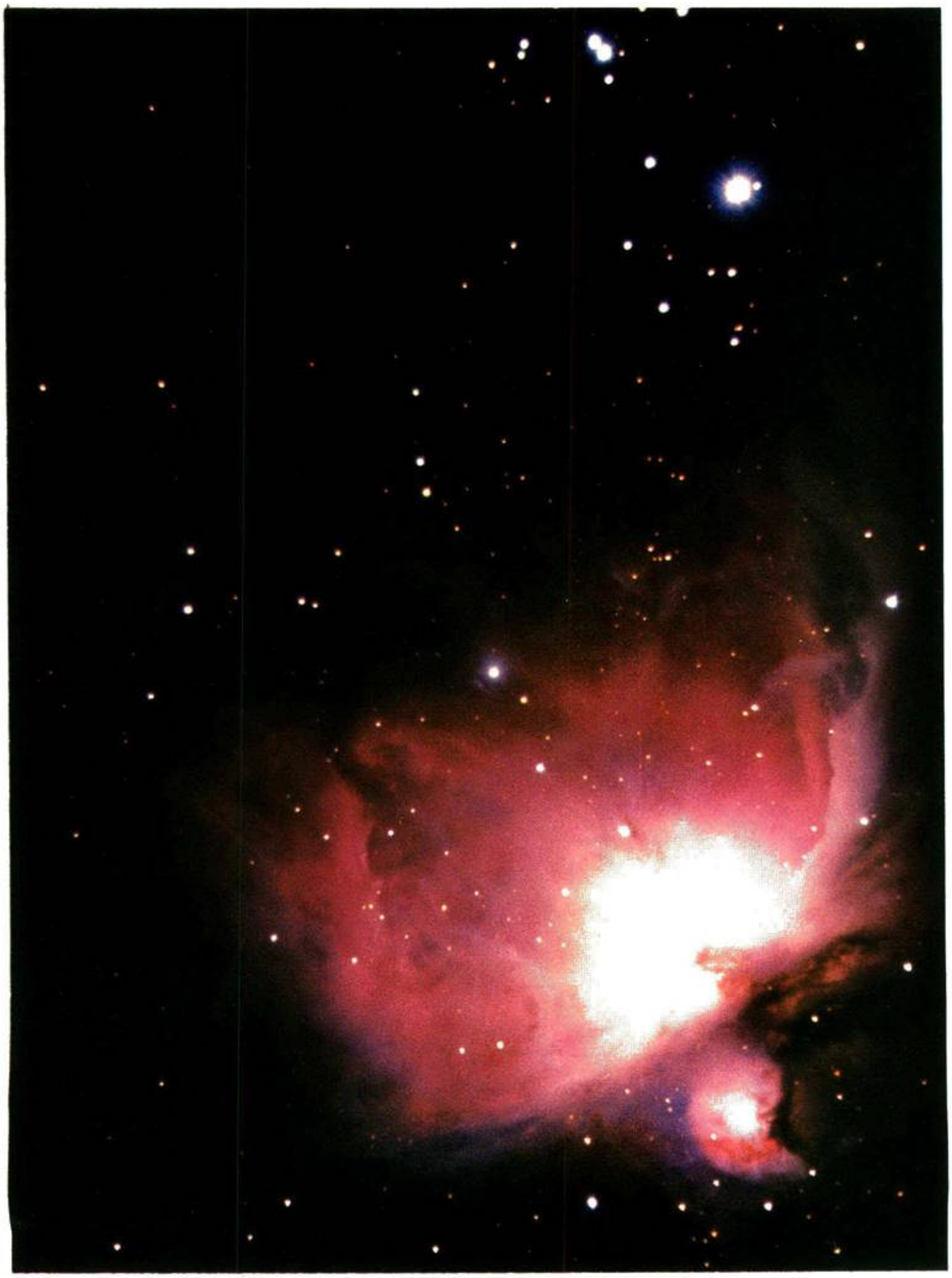
A RESPLENDENT CELESTIAL FLOWER, the Orion Nebula contains features with a large range of brightness that demand extra care in darkroom printing. Photos by the author.



Enlarger lens setting:		f/5.6	f/8	f/11	f/16
Exposure times:	(thin)	5	10	20	40
	(average)	10	20	40	80
	(dense)	20	40	80	160

The table gives equivalent exposure times in seconds at several f/stops for three possible exposures with thin, average, and dense areas of a negative. (Each negative will impose a different range of exposures, which you must determine by trial prints — see text.)

A LITTLE CARE REALLY HELPS. A straight, unmanipulated print (below) loses detail in both the outer regions and the central Trapezium; these areas emerge with proper dodging and burning (center and pages 68-69). But move the dodging tool constantly or you'll get artificial "ghosts" (right).



hanger, for instance) with a serrated piece of cardboard secured to the end of it. (See photo on page 72.) Paint the whole thing flat black, including the cut edges, to reduce potential glare. Make several tools in a variety of sizes.

Make a burning tool from a sheet of opaque material such as artists' matte board. The board should be 50% larger than the print paper. Cut a hole into the center of the board. Again make several tools, each with a different-sized hole, and paint each flat black.

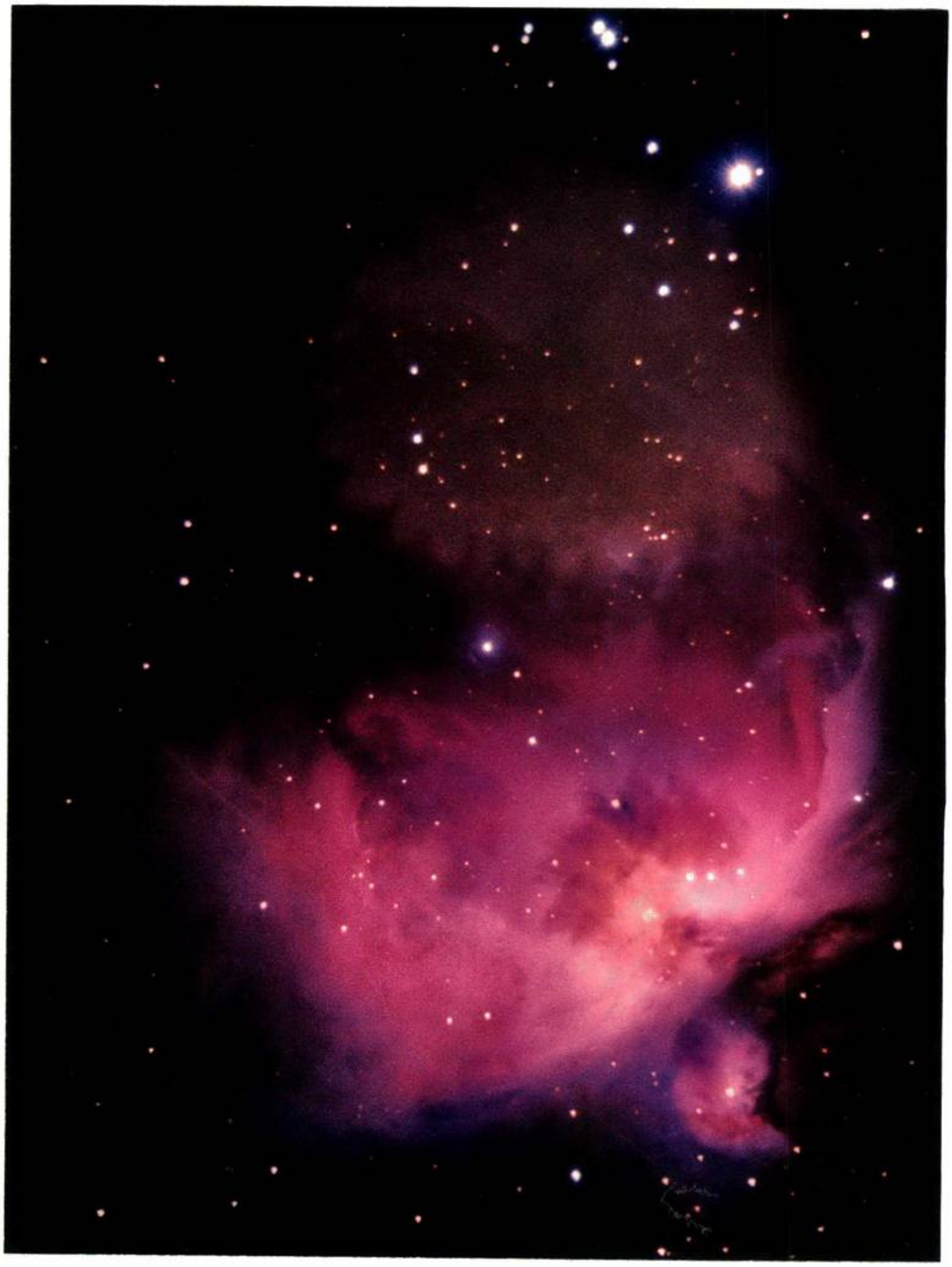
Burning and dodging is actually easier to do than to describe. The first step is to make a test-strip print to determine the exposure for the brightest and darkest areas. (For background, see "The Joy of Color Printing," November 1989.) When the enlarger is at the right height, orient the print easel so the densest part of the negative lies at the end receiving the heaviest exposure in the test. Be sure the faintest *significant* feature in the object also lies within the test print, ideally at the low-exposure end.

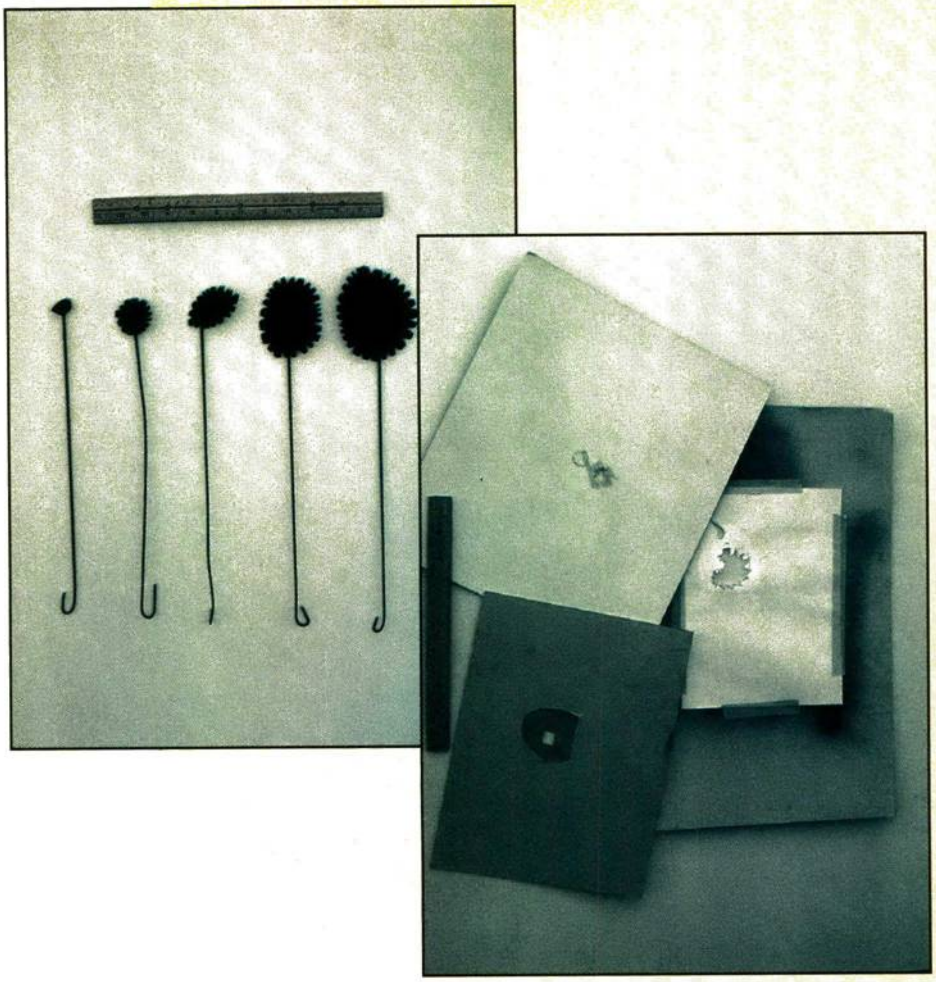
How Much and How Long?

Because enlargers, light sources, sizes of print, color filter combinations, and negative densities all differ, there's no single formula for every case. In the following, take my own settings for an Orion Nebula print as an example only.

Starting with the enlarger lens wide open and covering all the test print but a 1-inch-wide strip at the Trapezium end, I turned on the enlarger for 20 seconds. Then I moved the open area back 1 inch, covering the first strip but exposing a new one. I closed the lens one stop and made another 20-second exposure. I repeated the process until I reached the far edge of the test print and had closed the lens as far as the f/stops allow.

Developing several such test prints (adjusting for color balance in the process) told me that using a fixed 20-second exposure, the Trapezium needed an f/stop of 5.6, while the outer fringes needed f/16. I also found that a 20 second exposure at





DODGING TOOLS ARE SIMPLE TO MAKE from artists' matte board and coathanger wire, while a burning tool is an oversized sheet of the same board with a hole cut in it. (Ragged edges make for smoother results.) Construct several of each in different sizes for greater flexibility.

The Orion Nebula negative used for the examples was taken with an 11-inch SCT at f/6.3 on hypersensitized Konica 400 with a 40-minute exposure. In the darkroom I used a Beseler 23CII enlarger with color head, Kodak Ektacolor Plus F print paper, and Kodak Ektaprint 2 chemicals.

f/11 produced a semi-balanced print that resembled the sort of thing you could expect from an ordinary photo processor: a bright Trapezium (no detail), good nebulosity in the middle regions, and almost no fine detail in the outer areas (see pages 70-71). I call this the "base print."

I then prepared to make another base print, this time with some magic. But first, a few simple calculations and planning. The test print showed it took 20 seconds at f/5.6 to produce a nice Trapezium, 20 seconds at f/11 to produce my base print, and 20 seconds at one stop less light (f/16) to get detail in the outer areas.

I set the enlarger lens at f/11 and turned on the exposure for 20 seconds. When 10 seconds had elapsed, I began dodging the outer regions with the largest tool I had. I held it in the cone of light from the lens, well above the print surface, and kept it moving constantly. (This is essential to avoid a fake-looking artificial edge.) When the 20 seconds were up, I left the print in place and kept the darkroom lights off as I prepared for the second half of the procedure.

Enter the Magic

At this point the print was properly exposed for both the outer regions and the middle range, but the Trapezium area was way underexposed. So I opened the lens to f/5.6 and reset the enlarger's timer to 15 seconds. Why 15 seconds and not 20? Before starting this print, I had worked out the timer setting as follows: The table on page 70 shows that a 20-second exposure at f/11 equals a 5-second exposure at f/5.6. The test print had shown me that the Trapezium needed 20 seconds at f/5.6. Since the Trapezium has so far gotten 20 seconds at f/11 (equivalent to 5 seconds at f/5.6) I therefore needed to give it 15 seconds more at f/5.6.

With the timer set to 15 seconds and the lens at f/5.6, I held the burning tool in place over the print (but not touching it) and started the timer. Quickly I placed the burning tool's hole over the Trapezium and kept the tool moving around and around erratically, but always centered on the Trapezium. When the light snapped off I processed the print as I had the base prints. The result (see pages 68-69) was a pleasing combination that displays maximum detail in all parts of the nebula.

You can burn a region as long as you like, but I keep burning time to a minimum. The longer the print paper is exposed, the more its color shifts. In especially tough cases, when you need extended burning time even with the lens wide open, you may have to alter the filter pack.

The Orion Nebula makes a good illustration because it needs both dodging and burning. You'll probably find, however, that most celestial objects call for just one or the other. Although burning and dodging are easy to learn, not every application of them will be simple — complex shapes can pose great difficulties. Figure on spending a quantity of print paper in mastering the processes.

You should always keep in mind that dodging and burning are crafts, not scientific procedures. Despite the most careful notes — which I strongly recommend — it's unlikely that any two prints will come out exactly the same. Therein lies both the fun and the challenge.

Dodging and burning are among the simplest exposure manipulation techniques to learn. Like most acquired skills, they do take practice. And as you become better at them, you'll likely come up with your own personal methods. Great — go for it! And good luck! ☐

Larry Myers is a California astrophotographer. His last ASTRONOMY article was "The Joy of Color Printing" in the November 1989 issue.

PRODUCT REVIEW

Serious Imaging: ASTRONOMY Reviews a Top-of-the-Line CCD

The STAR I/A CCD camera with IPLab image-processing software is pricey, but perfect for amateur astronomy clubs, schools, and universities.

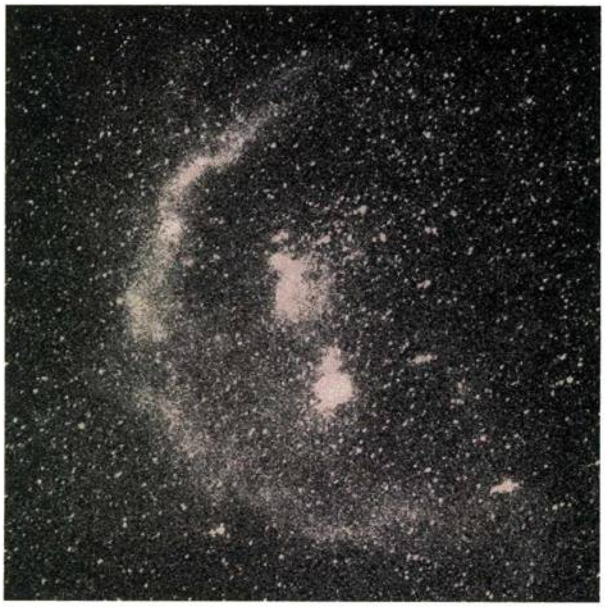
by Richard Berry

Amateur astronomers are rapidly adopting equipment that only a few years ago was entirely the domain of professional astronomy. A key item in the arsenal of professional equipment is the electronic camera, or CCD camera. Professional astronomers use CCD cameras because CCDs are much more sensitive than photographic film and because CCDs record light with extremely high precision.

As amateurs begin using such equipment, it's important that they understand exactly what benefits it offers to them. What can a CCD camera do that older technologies (such as photography) cannot do? What can a sophisticated CCD camera do when it's used on an amateur-sized telescope? What kind of standards does professional-level equipment set for the CCD cameras targeted to the amateur market? Who is the STAR 1 camera most suitable for? Individuals? Astronomy clubs? Teachers at small colleges?

We conducted our appraisal of the Star 1 camera with the specific purpose of answering these questions. We tested the camera on a small telescope (6 inches aperture) in a small observatory (eight feet square). We tried to push the camera to its limits of exposure time, of image quality, and of ability to capture faint objects. And we tried to assess, within the limits of our test program, who would most benefit from using such a camera.

The camera's manufacturer, Photometrics, loaned us a Star I/A camera for three months. Photometrics also supplied a camera controller unit, a 12-inch video monitor, a National Instruments GPIB IEEE-488 interface board, software to run the camera and board, and a set of manuals. The loan equipment was the package we felt best suited the needs of amateur astronomers. We installed the card and software in a 80386SX-based PC. As our test program drew to a close, we copied the two-dozen-or-so best images from the PC to a Macintosh IIcx computer. On the IIcx, we processed these images using software that Photometrics recommends, IPLab™ from Signal Analytics Corporation.



BARNARD'S LOOP in Orion glows in the light of H-alpha in this 20-minute exposure with the STAR 1 CCD camera.

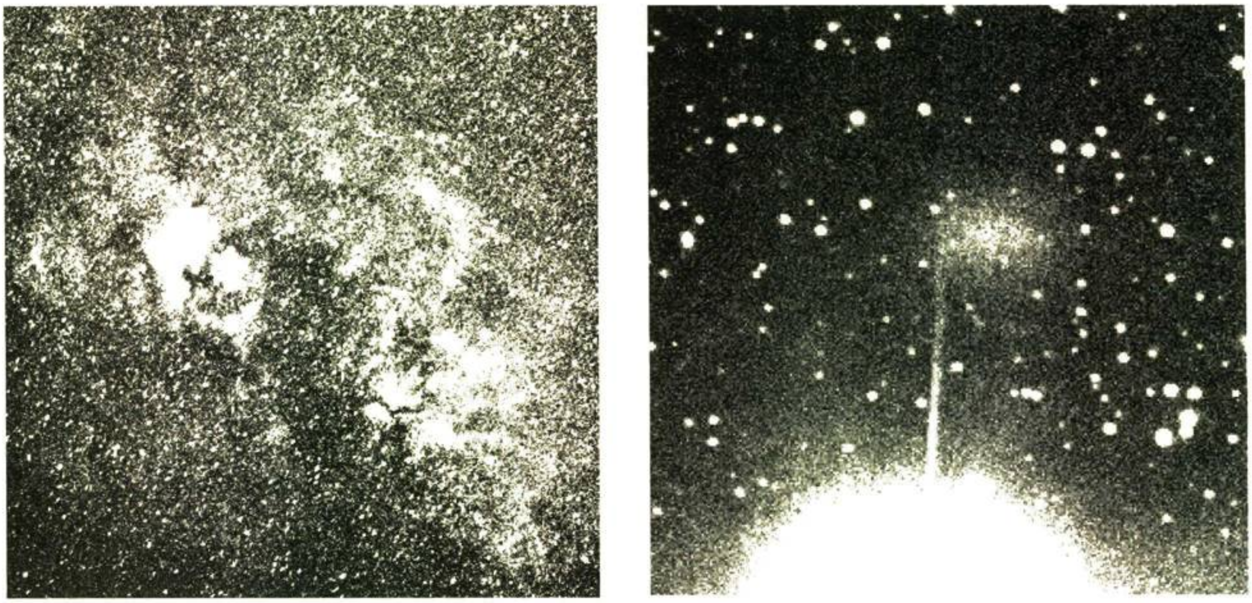
The camera and its associated equipment arrived in two large boxes. Although the camera itself is only 5 inches in diameter and 4.25 inches deep, the control electronics, monitor, and cabling together make it rather heavy and bulky. Add a PC and monitor to that and it fills the rear of a small hatchback.

We checked out the equipment in our offices. The manuals walk you step-by-step through attaching cables and hardware. The manual recommends testing the STAR I as a stand-alone system first and then integrating the computer, so that's what we did. Integration proved a little tricky.

Installing the GPIB (General Purpose Interface Board) was a snap — remove the computer case, snug the GPIB into the motherboard, close the case. The interface software is also easy enough to install. It's necessary to modify the CONFIG.SYS file to install the device driver GPIB.COM, but doing this is no more difficult than installing a mouse or VGA card.

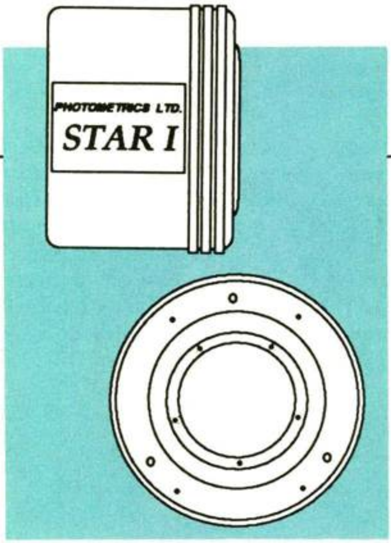
The STAR I control software, STAR.EXE, requires Microsoft Windows, and that did turn out to be a bit of a hassle. At the time we tested the STAR I, Windows 3.0 had been released, but the STAR.EXE software had not been updated. Photometrics assured us that STAR.EXE would be updated to run under Windows 3.0 by the time our review appeared.

Configuring the GPIB interface properly took about eight hours of effort. When we booted STAR.EXE, it told us the camera was not connected. Following the manual's suggestion, we opened up the equipment, checked all the switch settings on the GPIB, all the rocker switch settings in the control electronics, and all the software



THE RED, THE FAINT, AND THE BEAUTIFUL are captured with the STAR I. With a 28mm camera lens, an H-alpha filter, and a 1,200-second exposure, the STAR I recorded faint nebulae in Cygnus (left). The Leo Dwarf galaxy (right) is a faint dwarf galaxy near Regulus; it shows clearly in a 300-second shot with a 6-inch reflector. The glare at the bottom of the image is from Regulus.

Star I CCD Camera



A 576- by 384-pixel CCD camera with built-in shutter and Peltier-effect cooler. Pixels are 23 microns square. The STAR I is liquid-cooled and runs at a nominal -45 Celsius; the STAR I/A is air-cooled and runs at -30 Celsius. System includes controller, cabling, and manuals.

Manufacturer: Photometrics Ltd., 3440 E. Britannia Drive, Tucson, AZ. Telephone: (602) 573-1944, Fax: (602) 889-9933.

List Prices: STAR I or STAR I/A system, $12,100.00; Thompson TH7883 CCD chip, $2,750; GPIB-AT board, $550.00, PC2A-XT board, $450.00; IBM XT/AT camera control software, $450.00.

Pros: Scientific-grade CCD chip with large pixel count, 12-bit image data, air-cooled camera (STAR I/A), no need for coolant tubing, rapid image transfer to computer.

Cons: Expensive for an individual, setting-up requires technical expertise, efficient operating requires two persons.

setup screens, and put it all back together. Still no dice.

The manuals assume that the user has a fairly high level of technical knowledge. Even though we are reasonably familiar with computers and installing add-on boards and software, setting up a STAR I from the manuals alone proved frustrating and difficult. With the help of Alan Lichty from Photometrics, we traced our problem to an incorrect device-map configuration. Lichty told us that Photometrics is in the process of rewriting the manuals so that they will be clear to users.

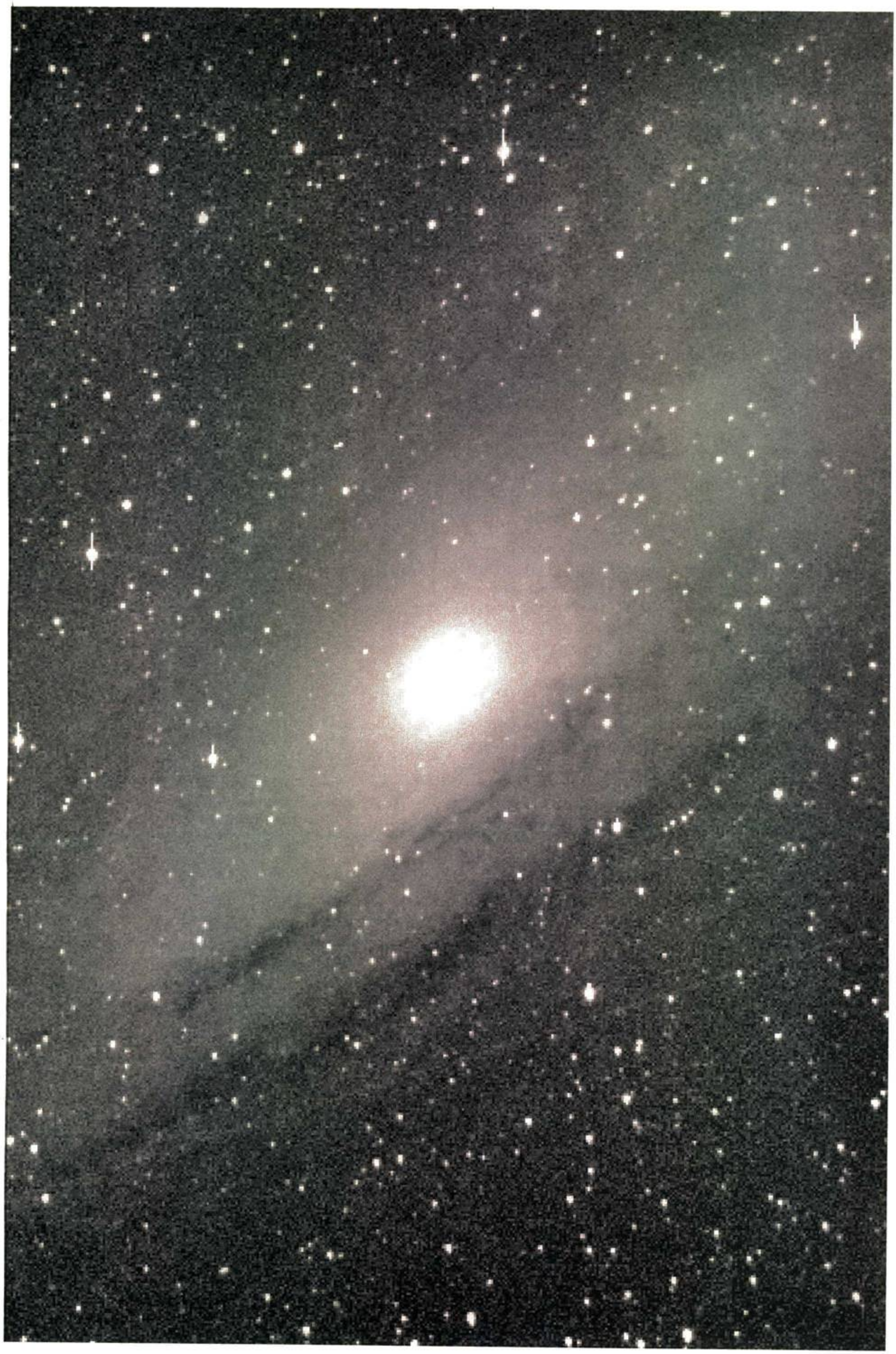
We installed the camera and its electronics in a small observatory equipped with a 6-inch f/5 Newtonian telescope, the same equipment used in our initial examination of the STAR I (ASTRONOMY, September 1990) and our review of the Lynxx and SBIG ST-4 cameras. We stacked the controller, computer, TV monitor, and computer monitor in one corner of the building and then snaked the camera cable around the telescope mounting and up to the focus of the telescope.

Because the observatory is so small (only eight feet square), the stack of electronic gear left barely enough space to turn around. This proved useful, however, because one observer could adjust the telescope and operate the computer and camera electronics without moving.

We took images on ten nights, usually in all-night or dusk-until-2:00 a.m. sessions. At dark we switched on the camera and electronics, and let everything warm up and stabilize for an hour. Toward the end of our test period, when evening temperatures were 25° Fahrenheit, the PC sometimes refused to boot until it had run for half an hour and warmed up. Even after it booted, the hard disk sometimes behaved erratically, refusing to load Windows until the fifth or sixth attempt. For any long-term observing program, you would want a heated computer enclosure.

Early each evening we would take flat-field frames as the sky darkened,

BOTH CORE AND OUTSKIRTS of M31 show in this 5-minute shot with the STAR I. Computer-processing squeezed bright and dark detail into one image.



IPLab Software

Billing itself as "serious image processing for the Macintosh II," IPLab offers the user a variety of image-processing algorithms for analyzing and enhancing images taken with a STAR I CCD camera. The program is extensible with C and Fortran routines and features a built-in scripting language for complex or repetitive image analyses. Special version controls the STAR I and can be used to take images at the telescope.

Manufacturer: Signal Analytics Corporation, 374 Maple Avenue East, Suite 200, Vienna, VA 22180. Telephone: (703) 281-3277, Fax (703) 281-2509.

List Prices: IPLab (image processing only), $499.00; IPLab-PMI (controls the STAR I camera), $899.00.

Pros: Supports gray-scale and pseudocolor image processing, reads images in a variety of formats, writes images in the same formats, and creates TIFF files for export to publication software.

Cons: To use effectively, requires a sophisticated understanding of image-processing plus some familiarity with mathematical functions and programming languages for scripting.

then try to locate targets setting in the western sky. To frame and center target objects, we used ten-second exposures. Once the object was centered, we ran several 300-second exposures and a dark frame.

The image data from the STAR I was excellent. Thermal noise in the STAR I is roughly one-tenth that of the ST-4 camera and one-third that of the Lynxx cameras, because the CCD in the STAR I is cooled to a lower temperature and the chip is a scientific-grade chip costing several thousand dollars.

The longest exposures we ran with the STAR I were 1,200 seconds, and we were limited in those by sky fog rather than thermal noise. Because of the low thermal noise, the STAR I camera would perform quite well on an f/10 telescope.

The computer-control program that controls the STAR I is Windows-based mouse-operated software. We found it easy to operate, fast, and responsive. You can set all the parameters through the keyboard and mouse, execute exposures, and save images to disk. You can also recall images from the hard disk and perform simple image-processing operations on them. We subtracted thermal noise and flat-field corrected each frame using STAR.EXE.

Compared to astrophotography with a 35mm film format, the STAR I covers a small field. On a 6-inch f/5 telescope, the STAR I covers a 50- by 75-arcminute field, compared to 2 by 3 degrees for a 35mm film frame. This is because the TH7883 CCD chip in the STAR I is 8.8 by 13.2 millimeters. For comparison, a 35mm film frame is 24 by 36 millimeters.

The CCD consists of an array of 576 by 384 pixels each 23 microns square. Although it depends on the emulsion type, most photographic films can resolve 15 to 20 microns. In coverage and resolution, the STAR I covers a smaller area and is less sharp than a 35mm-format photograph.

However, compared to the tiny 2.5 by 2.5 millimeter CCD chip in the SpectraSource Lynxx and SBIG ST-4, the chip in the STAR I is enormous. Acquiring and framing deep-sky objects was much easier with the STAR I than with the ST-4 or the Lynxx, and the resulting images covered a much larger sky area. On the other hand, the plethora of 441 kilobyte images from the STAR I very rapidly filled our computer's 40 megabyte hard disk; the 32- and 48-kilobyte files from the ST-4 and Lynxx were far easier to store and manipulate.

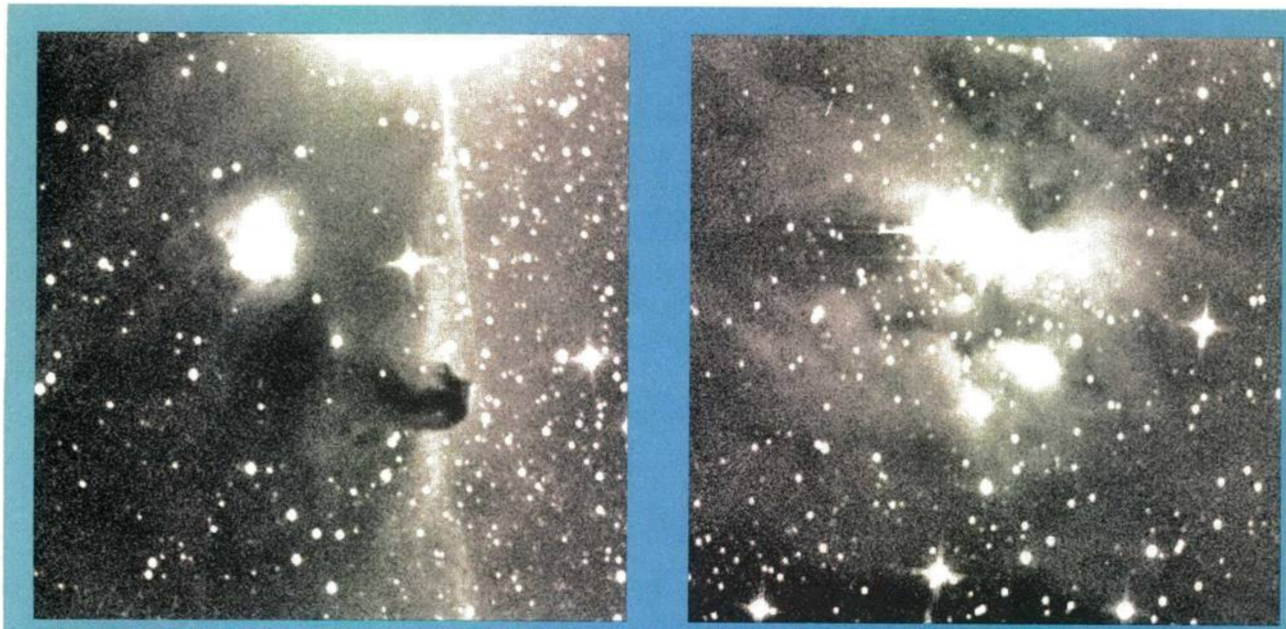
Photometrics recommends IPLab software for processing STAR I images. We transferred our best images to ASTRONOMY's Mac IIcx computer. IPLab is a powerful program intended for scientific image processing. You can load a STAR I image into memory, shift the numerical values of the pixels to new values, and sharpen, average, color-code, and save in a variety of image formats. We used IPLab for processing all of the images in this story; IPLab's logarithmic scaling capability converted ordinary-looking pictures into the images presented here.

Is the STAR I a good investment for amateur astronomers? It is difficult to recommend a camera that requires so much time and effort to operate, especially considering that even more time and effort are required to process the images once they've been captured. But conventional astrophotography, which competes rather effectively in image quality, cannot compete for speed, flexibility, and the sheer excitement one feels when working with the latest technology.

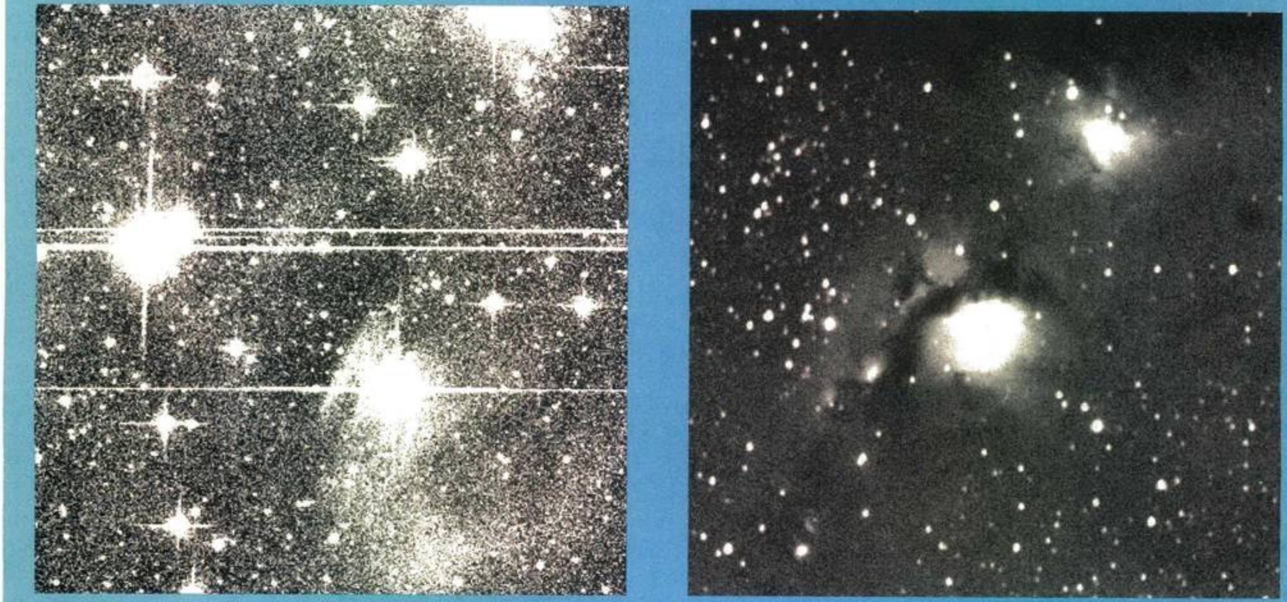
Our difficulty configuring the STAR I computer software suggests to us that users need technical support or at least someone familiar with electronics and computer jargon. Club and college environments often offer support that is not readily available to the individual user.

Furthermore, operating a computer and a telescope as well as the STAR I camera tends to be difficult for one person. Two observers are more efficient. A significant difficulty arises because a single observer loses night vision each time he or she starts a new exposure because the monitors, even when red-filtered, are fairly bright. Having one observer to run the electronics and one to run the telescope would be ideal.

This suggests that STAR I represents an excellent acquisition for an astronomy club seeking to enhance its club observatory. Rather than invest more money in a larger telescope, a club might want to invest in a more powerful image sensor. The CCD images that we obtained with a 6-inch reflector are comparable in limiting magnitude to photographs in our files at ASTRONOMY made with 16-inch telescopes, and the STAR I exposures were typically 3 minutes compared to the 45-minute exposures required for conventional astrophotography. For a group of serious amateurs sharing the cost, the STAR I would be a per-



FAMILIAR OBJECTS show more structure with the STAR I camera and IPLab software than with conventional photography. We captured the Horsehead and M43 in 300-second exposures and scaled the images logarithmically to show a wide range of brightness.



VERY BRIEF AND VERY DEEP EXPOSURES illustrate the STAR I's abilities. In just 30 seconds, the STAR I captured the reflection nebulosity that envelops the Pleiades. In a 600-second exposure, the STAR I shows the extent of interstellar material near M78.

fect addition to the club observatory.

At public star nights at a club observatory, the STAR I would allow club members to show the public a large number of deep-sky objects in a short time. Although electronic "viewing" for the general public flies in the face of conventional wisdom, the public is attuned to television viewing and would surely find it a great deal of fun.

The STAR I would also be superb in a university teaching observatory. Beside familiarizing advanced students with up-to-date imaging technology, the STAR I is great for giving student groups a quick tour of the sky. In the two hours of typical laboratory class, students could shoot images, process them, and print hard copy on a laser printer. On cloudy nights, students could load images taken earlier and carry out lab exercises using them.

In summary, we found the STAR I a powerful imaging tool capable of making a small telescope do the work of a much larger telescope. However, the high cost of such a camera and the technical prowess required to set it up and operate it suggest that clubs and educational institutions, rather than individuals, are in the best position to exploit the full power of this top-of-the-line CCD.

We were extremely impressed with the capabilities of the STAR I CCD camera, and found IPLab a powerful (and virtually indispensable) tool for bringing out the full potential of the images created with the CCD camera. As prices come down, the CCD will find an enduring place in amateur astronomy. ☐

Galaxy Hunting in the Great Bear

The region of the Big Dipper holds some of the brightest and prettiest spiral galaxies in the sky.

by Richard W. Jakiel

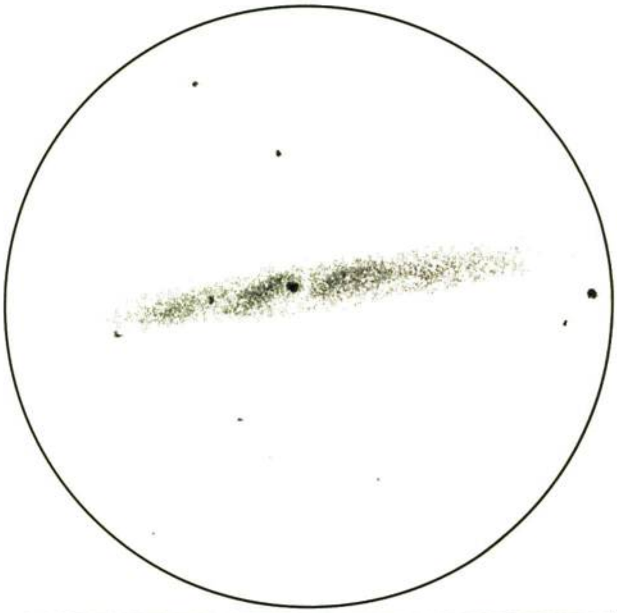
Richly laden with galaxies, Ursa Major is one of the best hunting grounds for deep-sky objects. The Great Bear ranks fifth among constellations in numbers of deep-sky objects, with more than five hundred bright objects. Nearly all of these are galaxies and many are visible even in small telescopes. If you look at only the showpiece objects such as M81, M82, M101, M108, and M109, you'll miss galaxies even more spectacular than the so-called showpieces. With an 8-inch or 10-inch scope and a little planning, 150 to 200 galaxies are visible within the boundaries of Ursa Major. Many of the best and most interesting objects are not found among the brightest handful.

Most of these galaxies are part of the "Ursa Major Cloud," an extension of the Virgo Supercluster of galaxies, to which our own Local Group belongs. Many of Ursa Major's galaxies are "late-type" spirals and barred spirals. Late-type spirals are distinguished by bright H II regions of ionized gas and OB associations of hot young stars along with prominent dust lanes. Many of these structures are visible in medium to large backyard scopes. Additionally, most of these galaxies are highly inclined to our line of sight. In fact, nearly a third of them appear edge-on from our perspective.

Perhaps the best place to start your tour is in the vicinity of Merak (Beta Ursae Majoris), the southernmost pointer star in the Big Dipper. About 1.5° southwest of this star is **M108** (NGC 3556), a spectacular edge-on galaxy. At magnitude 10.0, M108 is visible in any telescope. In my 8-inch f/7 scope, the galaxy looks like a fat cigar lying at the end of a chain of 7th- to 9th-magnitude stars. Several bright and dark areas are visible along the galaxy's main axis. The bright areas are regions of high density stars and gas, and the dark areas represent dust.

In my 20-inch scope at 175x, M108 spans better than one-third of the field. It is elongated about 4:1 in an east-west orientation. The galaxy's surface is unevenly bright, with several bright condensations separated by dark rifts and bars. A 12th-magnitude star located nearly "dead center" looks like the nucleus of the system, but is actually a foreground object. M108 has a high surface brightness, so don't be afraid to use medium to high magnification (10x to 20x per inch of telescopic aperture) to examine surface details.

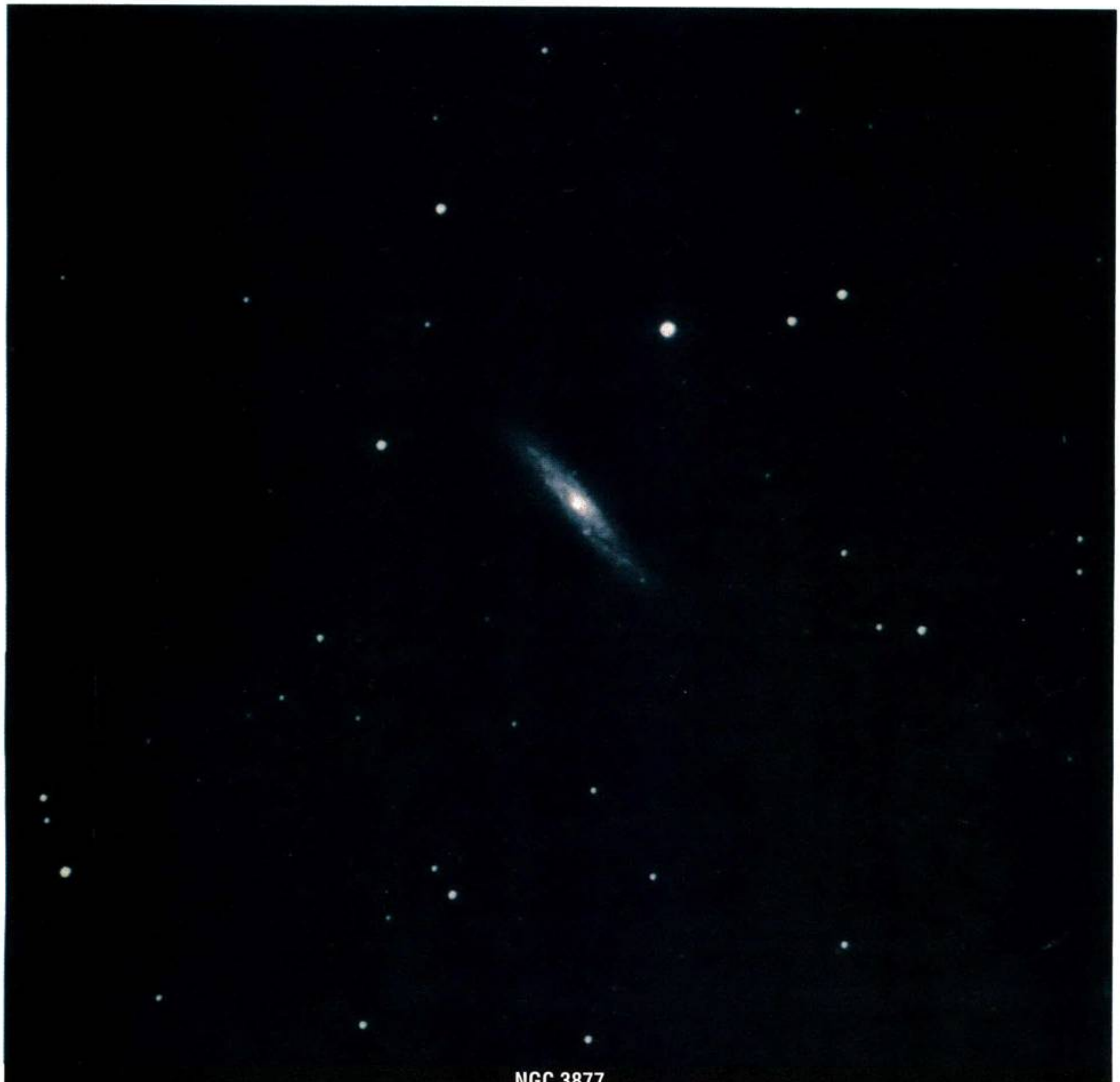
Less than 45' southeast of M108 is M97, the Owl Nebula. This bright planetary nebula lies well within our own Galaxy, and offers a welcome change of pace during a night of galaxy observing. Forming a nice triangle with M108 and M97 is **NGC 3594**. This galaxy offers a good test of your observing skills because it glows dimly at 15th magnitude. In the 20-incher I saw only a faint, oval patch with a slight condensation.



M108 20-inch f/4.5 reflector at 175x
Sketch by Richard W. Jakiel

About 2° southwest from NGC 3594, near the star 44 Ursae Majoris, is **NGC 3448**. It lies southeast of the star in the same low-power field. This object is an edge-on star system about half the size of M108 and about 1.5 magnitudes fainter. In the 8-inch scope, I saw a silvery streak about 2' by 0.5' that was weakly mottled and had a modest core region. In the 20-inch, the dimensions expanded to better than 4' by 1'. Overall, the texture is mottled. This object has a halo of rather low surface brightness, with several small, bright condensations spread along the galaxy's soft light.

About 2° southeast of M97 lies one of the brightest members of the Ursa Major Cloud, **NGC 3631**. This object is a large, face-on spiral with a total magnitude of 10.4. In the 8-inch scope I observed a small, bright core surrounded by a faint, diffuse outer halo. With the 20-inch scope I was able to discern a tiny, stellar nucleus



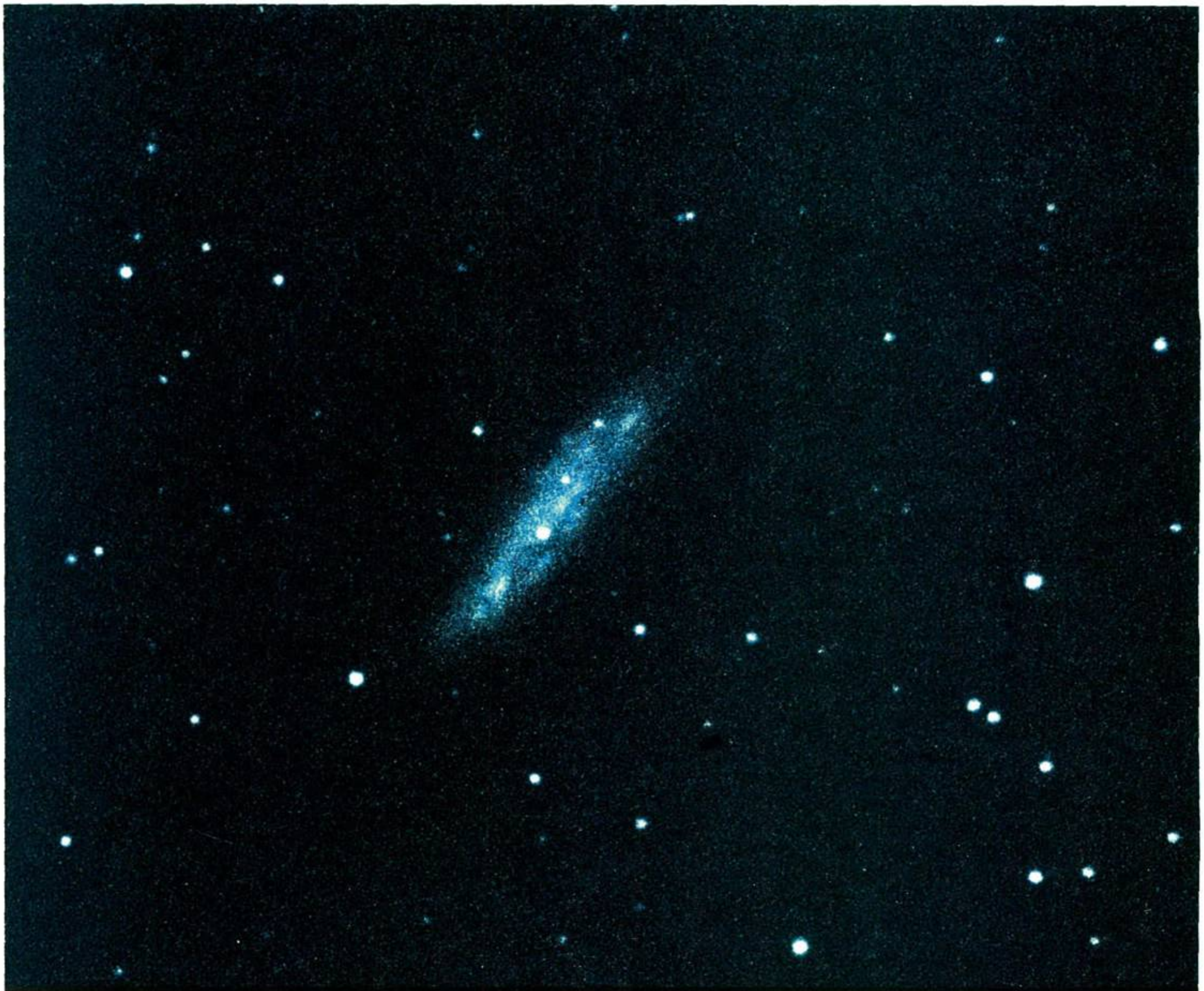
NGC 3877
Mag. 11.8 Size 5.4' by 1.5' by Preston S. Justis

embedded within a mottled core region. The round halo was nearly 5' across. Very faint knots were also visible; these may be giant H II regions and OB associations, places where stars are forming and shine newly born.

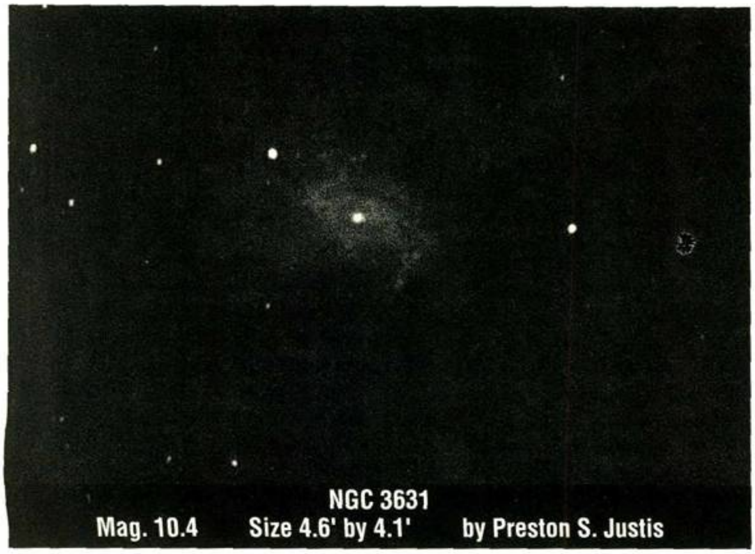
Moving southward, the number of galaxies drops off rapidly. But there are a few bright galaxies within this sparse region. The most notable is **NGC 3675**, a bright, highly inclined spiral. It is an 11th-magnitude object located in an otherwise desolate part of the sky. In the 20-incher, the galaxy is oriented north-south and is elongated about 2.5:1. The core is oval and has a bright, tight nuclear condensation. On the east side of the core, an arclike dark lane of dust is clearly visible. Overall, I estimated the dimensions of the halo to be about 5' by 2' in the 20-inch scope. The halo has a high surface brightness .

Lying over 4° northeast is **NGC 3726**, a spectacular spiral galaxy. It is bright, at 10.4 magnitude, making it easy to see even in small scopes. This is one object that really has a visual impact in a large backyard scope. In my 8-inch scope I saw a large, oval object with a small, moderately dense core. It is aligned nearly north-south, and has a mottled surface texture. The true nature of the object is best revealed in a large scope, however. In the 20-incher at 175x, I saw a roughly ellipsoidal object with low-contrast spiral arms. I estimated the object measured about 6' by 4'. The northern arm is weak, with small knots outlining the structure. The southern arm is much more prominent, making a sharp turn to the east. Numerous H II regions help delineate the structure. The core is a short bar aligned with the long axis of the galaxy.

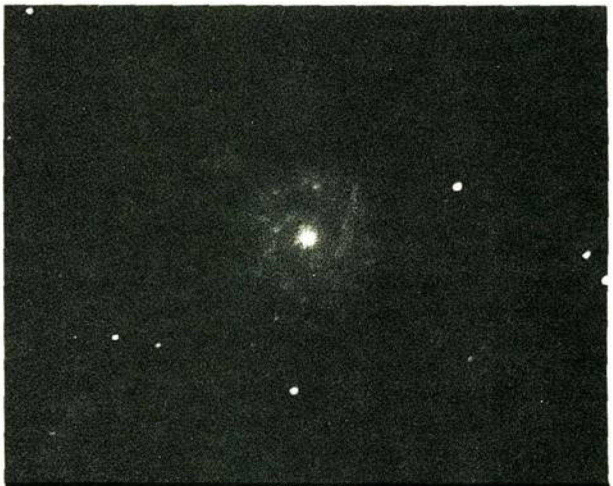
Just south of the bowl of the Big Dipper is a pair of interacting galaxies — **NGC 3718** and **NGC 3729**. NGC 3718 is easily the most peculiar bright object in this part of the sky. It is listed in Halton Arp's rogues' gallery, the *Atlas of Peculiar Galaxies,* as Arp 214; and this large, distorted barred spiral glows at 10.4 magnitude. With



M108
Mag. 10.0 Size 8.3' by 2.5' by Gary Hug



NGC 3631
Mag. 10.4 Size 4.6' by 4.1' by Preston S. Justis



NGC 3726
Mag. 10.4 Size 6.0' by 4.5' by Preston S. Justis

my old 8-inch scope I didn't see much detail, only a large, nearly amorphous patch with a slight central condensation. When I peered through the 20-inch scope, the view was more fascinating. The first thing I noted was an unusual dust lane bisecting a nearly round disk. The dust lane was narrow near the nucleus and it gradually broadened away from the core. Overall, the dust lane resembled a huge "bow tie," similar to the appearance of the dust lane in NGC 5128 in Centaurus.

Lying in the same low-power field, NGC 3729 is a small, distorted galaxy. In the 8-incher all I could see was an elongated patch of light glowing at 11.5 magnitude and oriented nearly north-south. This object is definitely smaller and fainter than its neighbor. In the 20-inch scope it looked like an irregular oval of nebulosity. A low-contrast central bar formed the core of the object. With averted vision I could detect low-contrast irregularities along the axis of the bar.

About 1.5° due south of Phecda is the bright galaxy **NGC 3953**. This galaxy is a large, diffuse object oriented northeast-southwest and elongated about 2.5:1. In the smaller scope, I saw a bright stellar nucleus and a faint star in the western part of the halo. Switching back to the 20-inch scope, I observed low-contrast dust lanes near the oval core.

Much more interesting is the edge-on type S0 galaxy **NGC 4026**, an 11.7-magnitude object located only 1° northwest of NGC 4088. It has the classic "spindle form" typical of S0 galaxies. This shape is easy to see in a medium-sized scope, and in the 20-inch scope it looks a lot like its photographs. This galaxy has a high surface brightness. The "ends" taper down to points. Overall, this object looks like the classic example of a spindle galaxy, NGC 3115 in Sextans.

Nearly 1° south of the NGC 4088/4085 pair lies another nearly edge-on system. **NGC 4100** is an 11.6-magnitude object of moderate surface brightness. Through my 8-inch scope I saw an elongated silvery streak oriented almost north-south. Both the 8-inch and 20-inch scopes revealed a small tight core, but in the larger scope the core appeared somewhat off center.

Skimming southward close to the Canes Venatici-Ursa Major border are two more large galaxies. The largest of these is **NGC 4144**, an impressive, though dim, edge-on galaxy. Glowing at a meek 12th magnitude, it is the faintest large galaxy in the region. With the 20-inch scope, I noted an irregular, low-contrast dark lane close to the diffuse oval core. Not far away, **NGC 4096** is about the same size as the 4144 system, but 1.5 magnitudes brighter. It has a high surface brightness and is highly elongated. The surface is quite mottled and the oval core has a small stellar nucleus.

NGC 4088 20-inch f/4.5 reflector at 175x
Sketch by Richard W. Jakiel

Dispersed around the 4th-magnitude star Chi Ursae Majoris are a number of bright galaxies. The most prominent of these is a large, low surface brightness spiral located in the same low-power field with Chi. **NGC 3877** is a medium-sized object glowing softly at magnitude 11.8. In my 8-inch scope, it looks like a fairly bright silvery streak with a moderately condensed core.

The last great galaxy group in the area lies near the double star 67 Ursae Majoris. About 2° northwest of the double you'll find **NGC 3938**, a very nice, magnitude 10.4 face-on spiral. When I viewed it with the 8-inch scope I saw a bright, round core surrounding a tiny nucleus. The galaxy's halo was large (about 4' across) and fairly faint. I did not view this object with a large scope, but photographs suggest that the spiral structure may be resolvable with a 17.5-incher.

Much closer to 67 Ursae Majoris is a pair of small galaxies, **IC 749** and **IC 750**. These galaxies are located close to a 8th-magnitude star about 1° west-southwest from 67 Ursae Majoris. IC 750 is the brighter at 11.8 magnitude, visible as a small nebulous streak with an irregular, "lumpy" core. In the 20-incher at 175x, I was able to resolve the core into three faint knots. IC 749 was barely visible in the smaller scope as a round, diffuse spot about 1' across. In the 20-incher, it was quite amorphous with a slight central condensation and the halo appeared to measure 2' across.

Our final objects, **NGC 4013** and **NGC 4051**, can be found north of 67 Ursae Majoris and west of NGC 3938. NGC 4013 is a thin, 12th-magnitude spindle of light. In the 8-inch scope it looks like a silvery needle with a slight central condensation. A 12th-magnitude star is superimposed near the center, masquerading as the galaxy's nucleus. NGC 4051 is a Seyfert galaxy, and like other members of this high-energy-output class it has an intensely bright starlike center. It is one of the brightest galaxies in the region, with a magnitude of 10.3. In medium-sized scopes, the galaxy's halo is quite elongated and the nucleus is easy to see. Using the 20-inch scope, NGC 4051 appears like a horizontally compressed "S," as short, faint arms are visible on both ends of the central bar. The nucleus is very sharp and bright, and the bar is rather smooth in texture.

Many other galaxies lie strewn across Ursa Major. And more are just across the border in Canes Venatici, such as those belonging to the NGC 4151 and M106 groups. The bowl of the dipper also contains many galaxies to explore. When you swing your telescope toward Ursa Major this spring, take a cursory glance at the super-bright galaxies you've seen many times. But then take some time to track down and study many of those lesser-known galaxies, whose special charm is unsurpassed by those in any region of the sky. ☐

Richard W. Jakiel is an enthusiastic observer living in Atlanta, Georgia. He sketches objects regularly, believing that "recording objects on paper is the best way to sharpen your eye."

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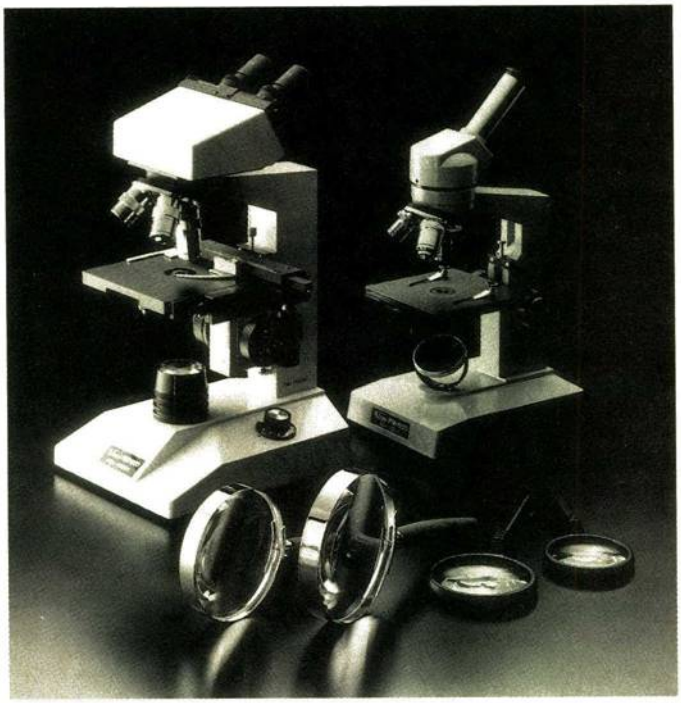

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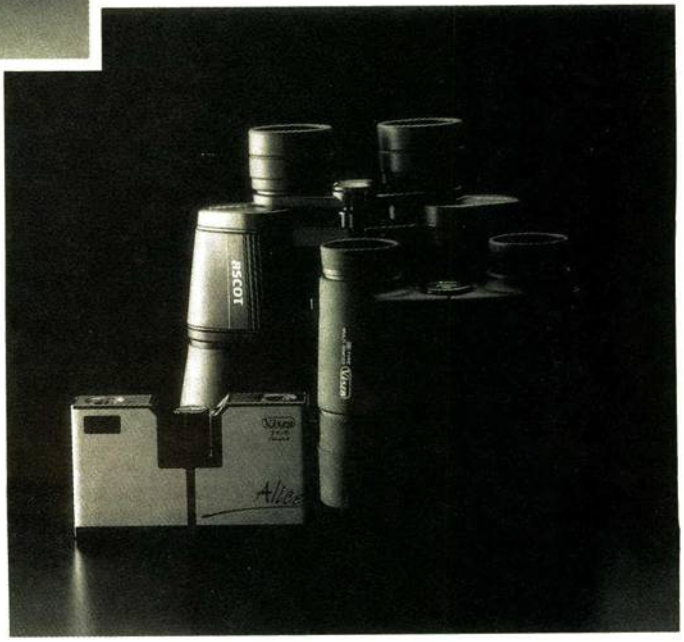

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SOLAR SYSTEM ROUNDUP

Reader submissions have been so heavy that we have been able to use only a small number of them. The following material summarizes some of our readers' observations of solar system events during the last weeks of 1990 and first weeks of 1991.

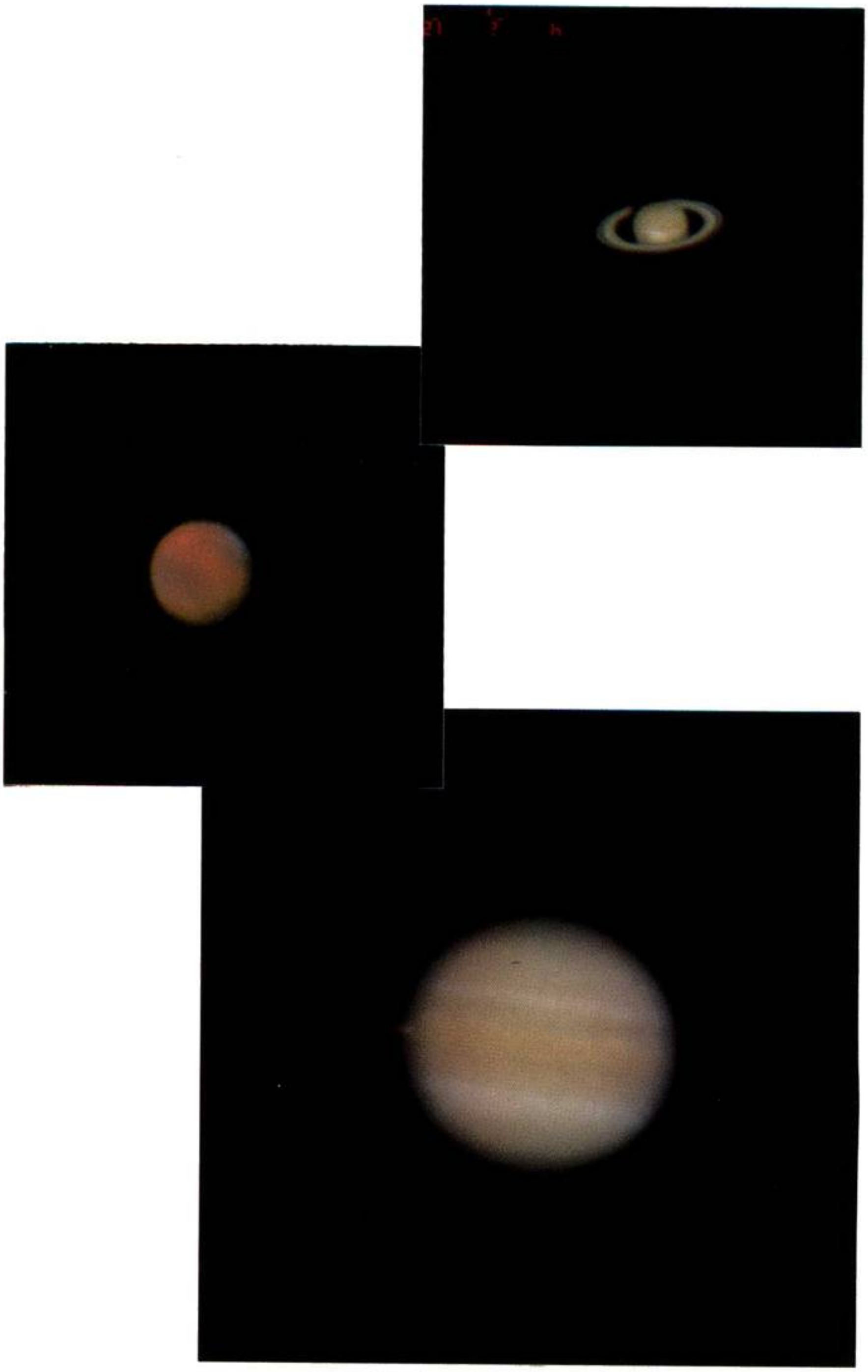
• **Saturn's Great White Spot**. In September 1990 Saturn surprised everyone by sprouting a giant white storm in its upper cloud layers. The object started as a white spot and then enlarged and smoothed into a long, oval shape that covered much of the planet's equatorial region. The feature appeared prominent in amateur scopes.

Dan Boyar of Boynton Beach, Florida, reported the spot was "not uniform in width and contained several lobes. By October 18 the white feature had spread out to the south."

"I am writing to report the existence of a large white spot, about the same size as Jupiter's Great Red Spot, on Saturn." So wrote Donald Abbes in a report about observations made from Keysborough, Melbourne, Australia.

From Erasamia, South Africa, Mauritz J. Geyser wrote that "on the evening of October 9 a friend of mine telephoned and requested that I look at Saturn and tell him what I saw. I set up my telescope and was astounded at seeing a kind of luminosity in the planet's western equatorial region."

• **Mars at Opposition**. Observers also had fun monitoring the Red Planet, which underwent scrutiny unlike any season since 1988. The planet was smaller at maximum diameter this time around but was placed higher in the sky for notthern hemisphere observers, making observations nearly as good as two years ago. "Although not as impressive as 1988," says Klaus R. Brasch, "we still enjoyed some pretty superb views." Brasch, a professor of biology at California State University at San Bernardino, regularly watched Mars for surface changes throughout this apparition. "The photo made on November 11, 1990, illustrates several of the most interesting aspects of the planet," he says. "The north polar region is enshrouded with haze and a bright area (a cloud?) lies just south of Solis Lacus, the so-called Eye of Mars. For me, visual and photographic monitoring of Martian atmospheric changes is one of the most exciting aspects of the hobby." — *David J. Eicher.* □



SATURN, MARS, AND JUPITER dominated planetary observing during the last weeks of 1990 and first of 1991. Saturn's great white storm was visible in backyard telescopes (top). Photo by Donald C. Parker. Mars reached opposition in November and small telescopes revealed a wealth of detail (center). Photo by Klaus Brasch. Jupiter's Great Red Spot regained prominence and the planet showed off outstanding belt details (bottom). Photo by Gregory Terrance.

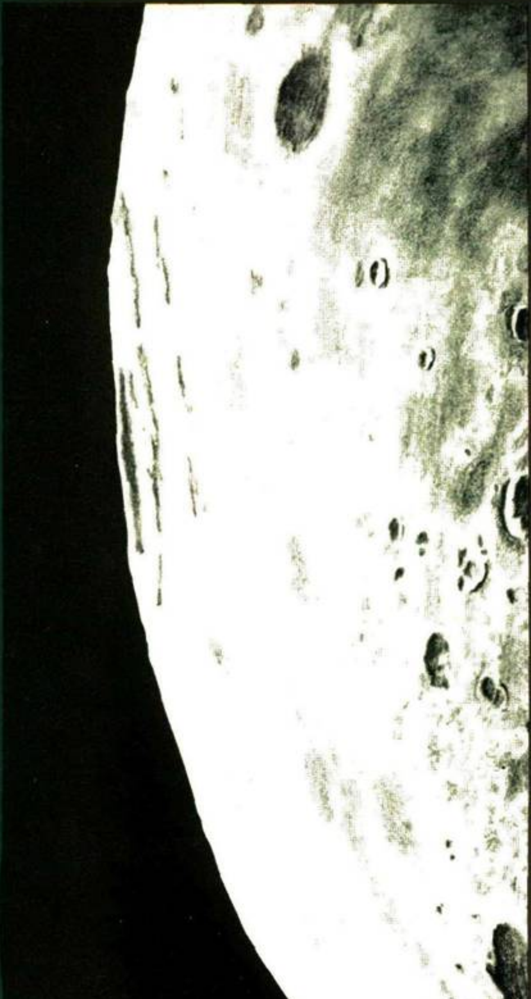
A SEA OF GLOWING NEBULAE

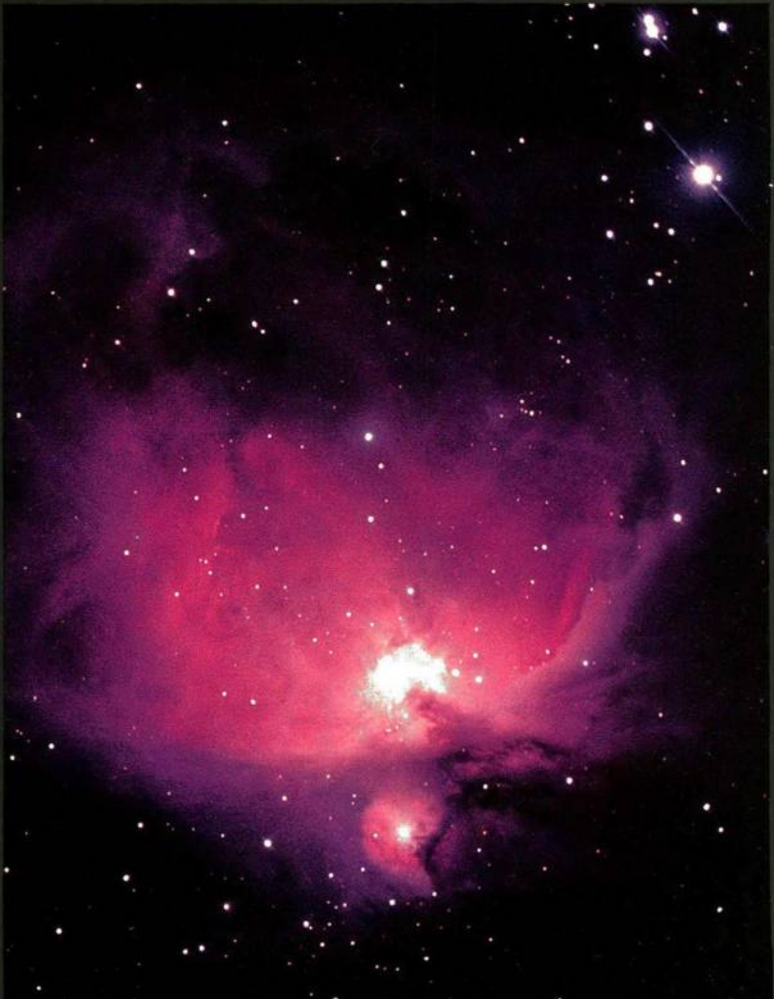
One of the richest regions in the winter sky surrounds the Rosette Nebula in Monoceros. Wider than two Moon diameters, this wreath-shaped stellar birthplace is faintly visible in low-power backyard telescopes. Michael Stecker's photo of the Rosette region (opposite page) — which also shows the Cone Nebula at the bottom — nets this month's $100 "Best Astrophoto" award. Stecker employed a 180mm f/2.5 lens, hypersensitized Tech Pan film, a hydrogen-alpha filter, and a 90-minute exposure for the photo.

Immediately west of the Monoceros region lies stately Orion, and its prime showpiece M42, the Orion Nebula. Bill and Sally Fletcher captured the subtle hues of the Orion Nebula in their photo made with a 16-inch reflector (below). The Fletchers used hypered Fujichrome Super HG 400 film for the photo.

Readers have also been recording the solar system in search of great images. Back on November 9, 1985, David L. Coleman of Dubuque, Iowa, sketched the Moon's limb at a time when the Mare Orientale basin was prominently visible (below left). Coleman sent a copy of his drawing after he was reminded of it while reading about Galileo's photograph of the Moon's far side.

Bright comets have eluded astronomers for a short time now, but Comet Metcalf-Brewington was visible in January 1991. On January 13 Jeffrey L. Jones of Tracy, California, recorded the comet and its very faint, short tail (left).





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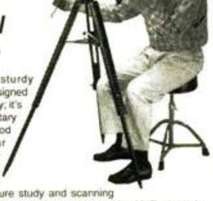

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Orion® Big Eye 8x50 & 11x80 Finder Scopes

NEW!

Ideal for upgrading any telescope including Schmidt-Cassegrains. Available non-illuminated or with wireless, adjustable, battery-operated illuminated reticle and Polaris grid for accurate polar alignment. With 90° diagonal prisms. Optional deluxe dual-ring brackets are perfect for 8" and 10" Celestron or Meade; will fit many others, too.

8x50 Models

The 50mm objectives gather 2.7 times more light than 30mm finders!

8x50 Standard Finder #7100 **$89.95** (3.31)
8x50 Illuminated Finder #7135 **$134.95** (3.56)
Bracket— For 8" & 10" #5143 **$25.95** (1.89)

11x80 Models

These huge finders gulp in over 7 times the light of 30mm finders; 2.5 times more than 50mm models! You might spend more time viewing through the finder than through your main telescope!

11x80 Standard Finder #7146 **$219** (4.16)
11x80 Illuminated Finder #7143 **$269** (4.16)
Bracket— For 8" & 10" #5140 **$37.95** (2.39)

SuperGiant™ 14x100 Binoculars

NEW!

Gigantic 100mm (almost 4 inch!) lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus improves alignment and allows for more precise focus. They feature Fully Multi-Coated optics and BAK-4 prisms. Comes with the integral platform tripod mounting plate and metal-clad case. 14x magnification, field of view 3.3°, exit pupil 7.0mm, weight 7.5 lbs., height 13.5".

#9495 **$799** (12.95)

Orion® Enhanced™ Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest-field available. Ideal for deep-space observation under dark skies. Hand-holdable.

#9502 **$349** (6.43)

16x80 MC-45% higher power, excellent for astronomy and daytime observation. Tripod recommended.

#9496 **$379** (6.43)

20x80 MC- Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required.

#9498 **$389** (6.43)

Orion® Little Giant™ 9x63 Roof Prism Binoculars

Popular mid-sized binocular, Fully Multi-Coated and remarkably lightweight. Excellent contrast and sharpness at center of field, with enough power to see lunar craters & Jupiter's moons. 5.5° field of view. Weight 2.8 lbs.

#9500 **$199** (4.80)

Orion® Sky Explorer™ Mini Deep Sky 8x56 Binoculars

56mm objective lenses gather over 2.5x the light of ordinary 7x35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view.

#9504 **$139** (4.16)

Superior Performance 7x50 Adlerblick Binoculars

Incredible wide field eyepiece design, Fully Multi-Coated, BAK-4 prisms, and best special glass objective lenses make the 7x50 Adlerblick the arch rival of European brand binoculars selling for 3-4 times the price. Orion buys direct, saving you money. Includes deluxe hard case, lens caps, straps.

#9612 **$269** (4.16)

Orion® 7x50 Observer™ Binoculars

NEW!

Our new Observer binocular is an ideal moderately priced night-vision binocular for both astronomy and general purpose daytime observation. Fully coated optics with a 7° field of view, and a bright 7mm exit pupil. Rugged ribbed rubber covering for a good grip.

#9620 **$84.95** (3.66)

StereoScope™ Binocular Viewing Expander

NEW!

Open up a new dimension in observation! The stereo effect of this viewer is astonishing. Viewing is more comfortable and it shows more detail, especially of the moon and planets. Specially built for astronomical telescopes, features a fully adjustable 55-75mm interpupillary distance scale and a highly precisce beam splitter which maximizes transmission of light to each eyepiece and equalizes the brightness of each image. Threads securely onto any Celestron or Meade Schmidt-Cassegrain. Includes a thread-on matched 2x Barlow lens. (Shown with two eyepieces, not included.)

#9720 **$399** (3.79)

Orion® 12.5mm Plössl Illuminated Reticle Eyepiece

NEW!

This new 12.5mm 4-element Plössl offers unprecidented eye relief and observing comfort during long astrophoto exposures. The battery operated integral illuminator has fully adjustable brightness. Features double crossline reticle.

#8484 **$99** (2.79)

World's Finest Illuminated Reticle Eyepiece

6mm Orthoscopic design for required high-power guiding, plus unique X-Y adjustable reticle positioning for easy guide-star alignment. Wireless LED illuminator has adjustable brightness.

#8487 **$139** (2.79)

Orion® 9mm Orthoscopic Illuminated Reticle Eyepiece

9mm Orthoscopic eyepiece with wireless adjustable brightness illuminator. Bull's-eye within three concentric circles helps measure limits of acceptable guiding error.

#8488 **$119** (2.79)

Orion® 12mm Kellner Illuminated Reticle Eyepiece

12mm Kellner eyepiece with cable plugs into LX/3, LX/5 and Premier drive bases, and most drive correctors with illuminated reticle output for polar alignment and guiding.

#8482 **$69.95** (2.59)

Orion® 2" Barlow Lens

NEW!

2x magnification, Multi-Coated, 2-element 40mm diameter achromatic lens. Baffled to eliminate off-axis glare. Works with all 2" barrel diameter eyepieces. Chrome plated brass barrel and blackened aluminum body with knurled set screw.

#8720 **$69.95** (2.59)

Orion® VariPower™ 2-3x Multi-Coated Barlow Lens

Our best barlow offers significant improvement over other models we've seen. The magnification is adjusted by sliding the internal lens cell along a calibrated scale (you don't have to poke a finger or pencil inside to do this). Fully Multi-Coated optics provide excellent sharpness, contrast and brightness. 1.25" diameter.

#8748 **$69.95** (2.59)

Orion® 3-element Fully Multi-Coated Barlow Lens

Fully Multi-Coated 3-Element Barlow lens provides superior imaging with precise color correction at three wavelengths. For maximum light transmission and highest contrast, we have used the finest quality multi-coating on each air to glass surface. 1.25" diameter.

#8750 **$59.95** (2.59)

Orion® Deluxe Fully-Baffled Multi-Coated Barlow Lens

Fully internally opaqued and baffled to block stray light for noticeably higher contrast. Large 27mm multi-coated 2-element lens provides 2x magnification with any 1.25" eyepiece.

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15mm-#8422 **$129** (2.79), *19mm*-#8423 **$139** (2.79)

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Incredible Fully Multi-Coated high-transmission 7-element eyepieces with integral rubber eyeguard and long eye-relief.

10.5mm- An incredible 67° field for outstanding planetary or deep space performance.

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#8554 **$119** (2.79)

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The finest zoom you can buy for your 1.25" telescope. An excellent choice for astronomy or terrestrial observing. 65°-35° field.

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Remarkably affordable, Multi-Coated parfocal eyepieces with great performance. Each carefully selected series has been chosen to provide a sensible progression of magnifications. Threaded for filters. Internally blackened to prevent stray light reflections.

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Orthoscopic Eyepieces-5mm #8500, 7mm #8502, 9mm #8504, 12.5mm #8506, 18mm #8524, 25mm #8526

$46.95 ea. (2.19)

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Get the most from your small telescope with these fine Multi-Coated eyepieces. Standard .965" barrels fit all Japanese standard small telescopes.

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9mm #8582, 12.5mm #8583

$37.95 ea. (2.19)

.965" Kellner Eyepieces
18mm #8584, 25mm #8585

.965" Achromatic Huygenian Eyepieces- 40mm #8586

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Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

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For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces.

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52mm Broadband Filter–For 52mm camera lenses, adapter rings available for other diameters.

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SkyGlow UltraBlock Filters-Visual Only
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter– fits 1.25" eyepieces.

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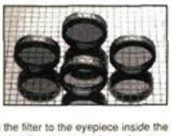
Schmidt-Cassegrain UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes.

#5656 **$99.00** (2.59)

Orion® Color Filters for Eyepieces



Solar system observations are dramatically improved by Orion colored filters. For visual use, thread one into the barrel of any standard eyepiece. For planetary and lunar photography, Schmidt-Cassegrain owners can attach the filter to the eyepiece inside the tele-extender. Can also be threaded directly into a universal camera adapter.

Basic Set of 4 Filters .965"- Includes #80A Blue, #58 Green, #25 Red, #15 Yellow.

#5510 **$29.95** (2.19)

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#5514 **$39.95** (2.19)

Expansion Set of 4 Filters 1.25"- Includes #21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.

#5516 **$39.95** (2.19)

Deluxe Set of 8 Filters 1.25"- Includes all the filters in our basic and expansion filter sets.

#5517 **$74.95** (2.79)

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$11.95 ea. (.99)

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664 **$14.95** (2.11)

1.25" #5662 **$14.95** (2.11)

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NEW!

These new Multi-Coated Plössl eyepieces are incredibly low priced! Good quality optics for sharp, clear images. Precision four-element Plössl lens elements mounted in sturdy aluminum barrels. Available in 12mm, 18mm, or 25mm focal lengths, with 1.25" barrels. Buy all three for less than some single eyepieces!

12mm-#8596
18mm-#8597
25mm-#8598

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Deluxe Eyepiece Case

Organize and protect your valuable eyepieces and other accessories. This durable case with double hinges holds up to 10 eyepieces plus barlow. Die cut foam insert for snug secure fit. O.D. 8-1/2"x12-1/2"x3-1/8".

#5913 **$17.95** (2.49)

Deluxe Metal-Clad Accessory Cases

Keep accessories and camera safe and clean. Diced foam inserts can be tailored to your needs. Sturdy handle, two latches, key.

Regular Case: 16"x12"x61/2"

#5920 **$49.95** (5.09)

Large Case: 191/2"x12"x61/2" #5921 **$69.95** (5.92)

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Designed for the field tripod with padded insert to separate wedge from tripod during transportation. Specifically made for wedge combinations of Schmidt-Cassegrain telescopes up to 10" aperture. Allows storage without changing polar alignment. This blue bag is made of tear, rip and mildew resistant 100% Cordura nylon.

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Eliminate dew problems with FlexiShield! Better performance, more rugged, and easier storage than rigid dew caps. Forms into a tube with the velcro closure, opens flat for easy storage and transportation. Fits your telescope tube snugly, with wide rubber padding and full-length velcro closure—needs no screws. Models to fit most telescopes.

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Orion's Dew Zapper is a sure-fire cure for dew problems on your 8" or 10" Celestron or Meade Schmidt-Cassegrain telescope. Dew Zapper gently replaces lost heat, bringing the corrector plate temperature slightly above air temperature.

8" Dew Zappers- fit all Meade & Celestron 8" Schmidt-Cassegrains

DC Model #3503, AC Model #3504 **$39.95** (2.39)

10" Dew Zappers- fit all Meade 10" Schmidt-Cassegrains

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Dew Remover Gun

Moisture that interferes with viewing dissipates quickly with this 12V DC, 156 watt warm air gun. Has 4-1/2' cord.

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Orion® Slow-Motion Adapter

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#7012 **$49.95** (2.59)

Orion® Dual Balance System

Unlike ordinary counter-weights, our system allows instant adjustment in both directions. Easily balances your scope to offset both piggyback loads or rear-cell cameras, 2" diagonals, and other accessories. Rigid, precision machined dovetail bar mounts to telescope in existing accessory holes.

For Meade SC 8"	#5150	**$74.95**	(4.65)
For Celestron 8" C-8	#5149	**$79.95**	(4.65)
For Meade SC 10"	#5152	**$84.95**	(4.65)

Starlite Red LED Flashlight

The Starlite is the only adjustable-brightness night-vision red flashlight. Lifetime solid-state LED can't burn out. Extra efficient electronic circuit for long battery life. Uses one 9-volt battery (not included).

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Astronomer's Flashlight

Indispensable and indestructible. Has special night-vision red filter and a diffusion lens for even illumination. An essential addition to your astronomy accessories. Requires 2 D-cell batteries (not included).

#5701 **$9.95** (1.89)

Rechargeable Battery Porta-Pack

12 Amp Hour Porta Pac

Ideal for operating your telescope plus higher power-consuming accessories such as an Orion Dew Zapper. Battery is encased in high-impact polystyrene. Carrying case of Cordura nylon with shoulder strap and handle. Wt. 10 lbs.

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Our newest off-axis guider for Celestron and Meade Schmidt-Cassegrain scopes. Easily adjustable prism allows wider choice of guide stars. Precision helical focuser for your guiding eyepiece. Adjustable camera focal plane position. Suitable for advanced deep-space astrophotography. Compare our price!

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Standard Off-Axis Guider

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Rack & Pinion Focusers

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These top quality focusers are designed for Newtonian reflectors. Fit any size tubes.

1.25" Focuser

Quality diagonal-cut rack for smooth focusing. Secure slide-fit eyepiece holder. Integral socket for single-stalk diagonal support if desired.

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2" & 1.25" Focuser

Large clear diameter ideal for larger scopes and wide-field optics. Precision diagonal cut rack. Long travel for visual and photographic use. Interchangeable 2" and 1.25" holders with set screws.

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See the world as it really is with Orion's new 45-degree erect image diagonal. Upside-down, backwards and topsy-turvy images can often confuse even the stoutest and most experienced observer. Turn it right-side-up with your choice of three models to select from.

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Star Diagonals

1.25" Star Diagonal
Primarily for astronomical use, lets you view at a right angle. Multi-coated, for 1.25" eyepieces.

#8763 **$39.95** (2.39)

.965" Star Diagonal
Same as 1.25" Star Diagonal, but with standard coated optics. Works with .965" eyepieces and eyepiece holders.

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2" Star Diagonal

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Orion® Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender
Use this Tele-Extender in conjunction with an eyepiece. Attaches to visual back of Meade or Celestron Schmidt-Cassegrain telescopes, and to 35mm camera with T-ring, sold separately.

#5125 **$27.95** (1.89)

Variable Tele-Extender
Uses an adjustable extension tube, allowing magnification to be changed without switching eyepieces. Attaches with T-ring, sold separately.

#5127 **$39.95** (1.89)

Universal Camera Adapters

Standard Universal Camera Adapters
Combination Eyepiece Projection Tube and Prime Focus Adapter for refractors and reflectors with 1.25" eyepiece holders. Use with T-Ring (sold separately) to match your 35mm camera.

.965" #5268 **$29.95** (1.89)

1.25" #5264 **$34.95** (2.39)

Variable Power Camera Adapter

Unique sliding barrel design allows variable projection distances during eyepiece projection photography, eliminating the need to change eyepieces when magnification changes are required.

#5262 **$44.95** (2.39)

Orion® T-Adapter

For prime focus photography. Use with T-ring to match your 35mm camera. For Meade, Celestron 4", 8", 10", 11", 14" SC. Can be used as 2" camera adapter.

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Product Reviews

TUTHILL'S POLAR ALIGNMENT SCOPE

Deluxe Precision Polar Axis Finder, *Roger W. Tuthill Inc., 11 Tanglewood Lane, P.O. Box 1086, Mountainside, NJ 07092, (800) 223-1063. $188. Southern Hemisphere version: $219.*

Polar alignment is one of those mysterious chores that many backyard astronomers have trouble with. I've found that even people comfortable with the mechanical workings of an equatorial mount can have difficulty precisely polar aligning their telescope. As a result, their mount tracks stars in a passable fashion but objects still drift out of the field after a few minutes. This is acceptable for casual stargazing, but not for prolonged planetary viewing or for long-exposure or high-power astrophotography.

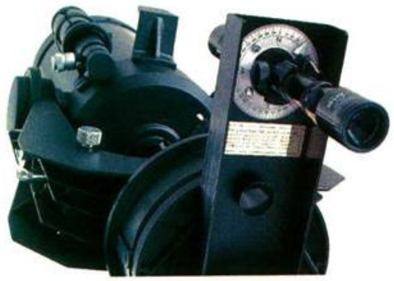
To aid users in precisely aligning a mount to the true Celestial Pole (which in the Northern Hemisphere sky lies 0.9° away from Polaris), manufacturers of many German equatorial mounts have included small sighting scopes built into the polar axis. The ones we've seen work well and make it much easier to get within a few arcminutes of the true Pole.

However, owners of fork-mounted Schmidt-Cassegrain telescopes have had to use a different technique. The method I've used for many years is to set the telescope to 90° declination and then use the finder scope to zero in on the Pole's position amid a specific triangle of stars next to Polaris. This works well for most purposes but does have two drawbacks: the finder must be very well aligned to the main optics, and the declination circle must be calibrated so that when it reads 90° the scope is truly aimed at 90°. If either of these adjustments is out of whack the polar alignment effort will be for naught.

To get around these problems, Roger Tuthill is offering a unique Polar Axis Finder telescope for Schmidt-Cassegrains. It attaches to the wedge and allows you to aim the mount at the true Pole without concern for how well either the regular finder scope or the declination axis is aligned. Always suspicious of new gadgets that proclaim shortcuts, I tried the Polar Axis Finder on a Celestron 8 telescope and was pleasantly surprised to find that it worked very well indeed.

On a series of trials over several nights, I found that by following the Finder's instructions I was able to align the telescope well enough so that after 20 minutes a star at the Celestial Equator would drift only 20 to 45 arcseconds in declination. The alignment procedure took about 2 to 3 minutes at most. While the results were still not perfect, the Tuthill Finder provided as good an alignment as I've been able to achieve without resorting to much more time-consuming star drift methods. The alignment was certainly good enough for most astrophotography applications except long exposures (20 minutes or more) at prime focus.

The Finder is actually a 4x30 Swift riflescope mounted in a bracket that offsets the optics by the correct 0.9°. The bracket attaches easily to the bottom of a Meade or Celestron wedge. To use the Finder you rotate the riflescope to a predetermined angle and then shift the altitude and azimuth of the telescope tripod in order to bring Polaris to the center of the riflescope crosshairs. This automatically aims the polar axis of the main telescope the right direction and distance away from Polaris.



PAINLESS POLAR ALIGNMENT is the goal of Tuthill's Polar Axis Finder accessory for fork-mounted Schmidt-Cassegrain telescopes.

The instructions contain a list of angles to set the Finder at on specific dates throughout the year and at certain times of the night. For other dates and times you need to add or subtract a specified number of degrees to find the correct setting. You also need to factor in a standard correction for your location, depending on how far east or west of the time zone boundary you are. Calculating the final setting is the trickiest part of using the Finder. For it to work accurately, you must be accurate in your calculations. In practice, the procedure is quite easy and the instructions provide clear directions and examples.

I was also impressed with the Finder's solid construction. The riflescope has a generous 4-inch eye relief and its image quality is quite good. However, some sort of illumination of the crosshairs would be helpful. One other caveat is that the Finder must be detached from the scope for packing, making for one more item to set up when assembling the telescope.

Is the Polar Axis Finder a required accessory? Avid astrophotographers may still prefer to use star drift methods to perfect their polar alignment, while very casual observers may not need such a device at all. And with care, the standard finderscope supplied with every Schmidt-Cassegrain *can* be used to provide reasonably accurate alignment. However, the Tuthill Polar Axis Finder does what it claims: with relative ease and assured, repeatable accuracy it can quickly align your telescope to the Celestial Pole. — *Alan Dyer*

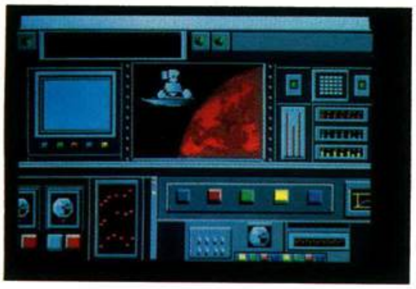
NEW SOFTWARE RECEIVED

Astro Labs, *Academic Software Development Group, University of Maryland, Computer Science Center, College Park, MD 20742, (301) 405-7600. Each lab: $175; Set of four: $600. For IBM and compatible computers.*

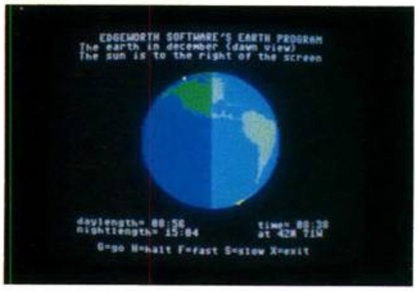
This software is designed for use in college-level astronomy courses. It consists of a set of four experiments that simulate actual astronomical observations and analysis, and includes experiments in measuring stellar parallax and galactic radial velocities. The program includes animated demonstrations to illustrate some of the concepts being explored.

Destination Mars, *Compu-Teach, 78 Olive Street, New Haven, CT 06511, (800) 44-TEACH or (203) 777-7738. $59.95. Available for IBM, Apple II, Apple IIgs, Macintosh, Tandy, and MS-DOS compatibles.*

This program simulates a flight to Mars, including landing the spacecraft, performing field experiments on the Martian surface, and erecting a Mars Base. Aimed at ages 11 to 17, Destination Mars is designed to develop critical thinking and decision-making skills as well as to educate the user in astronomy and related sciences.



Destination Mars



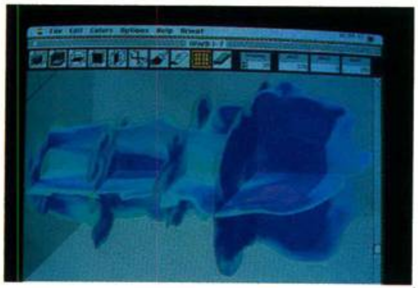
```
EDGEWORTH SOFTWARE'S EARTH PROGRAM
The earth in december (dawn view)
The sun is to the right of the screen

daylength= 08:56                time= 08:38
nightlength= 15:04              at 42N 71W
     G=go H=halt F=fast S=slow X=exit
```

Earth Disk One, *Edgeworth Software, P.O. Box 418, West Upton, MA 01587. $19.90. For Commodore 64 and 128 computers.*

Suitable as an educational program for children, Earth Disk One creates a large rotating globe on the screen that serves to demonstrate day and night, the four seasons, the midnight Sun, and the polar night. Users can select various view angles and rotation speeds.

Spyglass Dicer, *Spyglass Inc., 701 Devonshire Drive, C-17, Champaign, IL 61820, (217) 355-1665. $495.00. For Macintosh computers.*

Designed for the professional researcher, Skyglass Dicer converts volumetric data into three-dimensional displays consisting of slices and cubes. Data can be displayed using 17 built-in color tables or user-defined color palettes. Images can be printed in halftones or on color printers or exported to other programs as HDF or PICT files.



Spyglass Dicer (Image of supersonic jet courtesy David Clarke and Michael Norman of the University of Illinois, Urbana-Champaign) □

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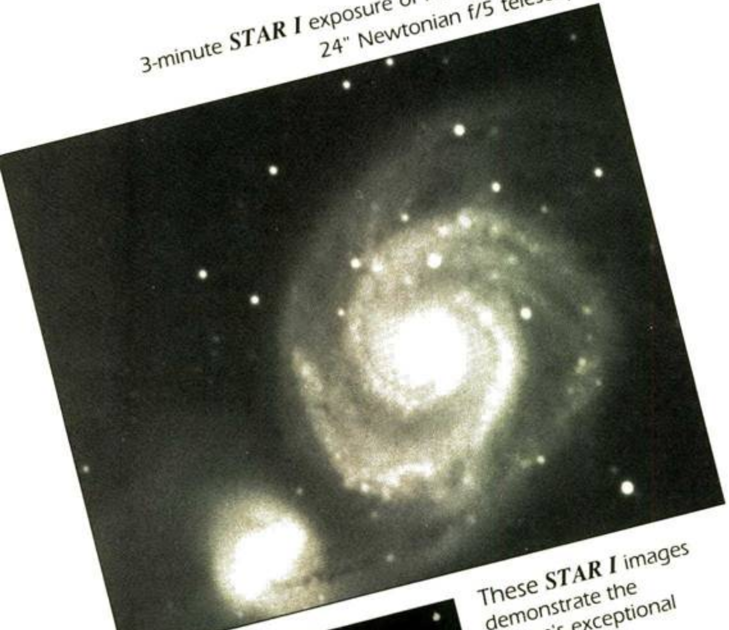
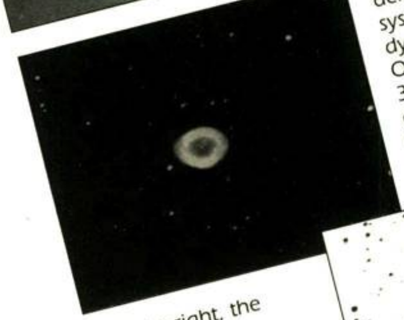
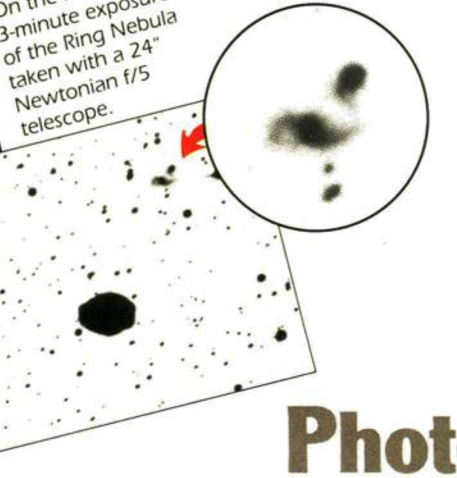
3-minute ***STAR I*** exposure of M51 taken with a 24" Newtonian f/5 telescope.



These ***STAR I*** images demonstrate the system's exceptional dynamic range. On the left is a 3-minute exposure of the Ring Nebula taken with a 24" Newtonian f/5 telescope.





On the right, the same image is inverted and rescaled to highlight the distant spiral galaxy, IC 1296.

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FOR SALE — *Telescope Making* #1, 2, 8, 13, 14 $5 each. *Planetary Astronomy* #1, $5. Also old issues of *Science Digest, Popular Science*. $1 each. *Ufo Review* #3, 5, 14, 15, 16, $2 each. *Ufo Prophecy* by Arthur Shuttlewood $5. Rubber Eyeguards for 1 1/4" eyepieces, $5 each. Trade: Vega 2 focuser for Meade #680 two-inch focuser. Contact Dan Isaac, RR1 Box 626, Danville, WV 25053. Phone (304) 369-2216.

WANTED — Twenty-six-year-old male, would like to correspond with people who know the art of polar alignment. (Would like step-by-step instructions. Plus, would like to find out more on astrophotography. I need to hear from you. Contact Andrew Bobbitt, 122 Sandy Valley Rd., Dedham, MA 02026. Phone (617) 326-6971.

WANTED — TeleVue Panoramic brass and wood alt-azimuth mount. Contact Terry Smith, 9 Fifth Street, SE, Linton, IN 47441. Phone (812) 847-2532.

WANTED — Male seeking correspondence with males and females interested in astronomy, space, Moon/Mars exploration, and NASA. Contact Gary Sark, 311 Markley Road, London, OH 43140.

WANTED — 15-year-old female seeks penpal from anyone similar age anywhere in the world. Interested in aviation, astronomy, and other sciences. Contact Melanie Angers, 5 Lemay Ave., Lewiston, ME 04240.

FOR SALE — ASTRONOMY, August 1973-present (missing May 1977). $150 plus shipping. *Sky & Telescope*, January 1971-present (missing January 1974). $150 plus shipping. *Scientific American*, January 1978-present (missing September 1979). $150 plus shipping. Contact Fred Lusk, 6086 N. Wilson, Fresno, CA 93704. Phone (209) 439-2380.

FOR SALE — 1985 Questar 3 1/2" standard, Pyrex mirror, all coatings, 8mm and 32mm Brandon eyepieces, full-aperture solar filter, camera adapter, leather case, and deluxe shipping drum. Mint condition. $2,500 plus shipping. Steve Snider, 2325 Green Lake Rd. NE, Rio Rancho, NM 87124. Phone (505) 892-5022.

FOR SALE — 8" f/14 refractor by D & G Optical. AT-10, Schaefer mount with 10" Byers drive, Hurst drive on declination, detachable declination shaft, alt-azimuth adjustments, circles, pier, counterweights, programmable dual axis quartz drive corrector. Valued at well over $8,500, all for $6,300 or will sell separately. Pickup only. Photo on request. Contact Joe Macrie. Phone (301) 868-5322 or (202) 906-6040.

WANTED — Do you like astronomy, physics, space exploration, science-fiction, books, chess! Well so do I, and I'd love to hear from you. Contact Jorden L. Celis, P.O. Box 968, Tecate, CA 92080

FOR SALE — 83mm refractor w/air-spaced, coated Jaeger's objective, including tripod, equatorial mount, clock drive, eyepieces, and star diagonal. Like new. $350. Contact J.L. Benton, 305 Surrey Road, Savannah, GA 31410. Phone (912) 897-4735.

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TeleVue Optics, Inc., 20 Dexter Plaza, Pearl River, NY 10965, (914) 735-4044. Model T and U: each $250.

2

Celestron S-55F Fluorite Spotting Scope

The 55mm aperture f/8 apochromatic lens system uses a fluorite lens element for excellent color correction and high contrast. Other lens elements are multi-coated. The spotting scope comes with a 22mm (20x) 1-1/4-inch diameter Plössl eyepiece, rack and pinion focusing, a 45° erect image diagonal,and a tripod block to attach to 1/4-20 photo/video tripods. Also available are optional camera adapters and other eyepieces.

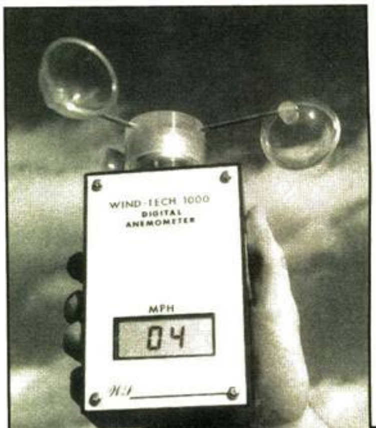
Celestron International, 2835 Columbia Street, P.O. Box 3578, 2835 Columbia Street, Torrance, CA 90503, (800) 421-1526 or (213) 328-9560 (8 a.m. to 4 p.m. Pacific Time). $1,198.

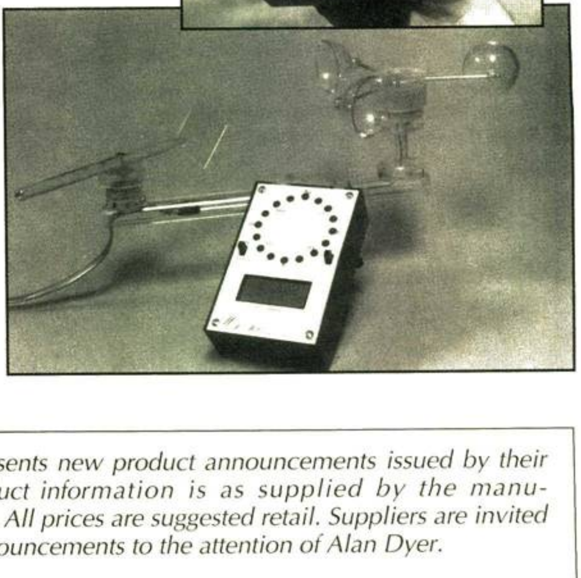
3

Professional Weather Station

The WILSEC WS100 Weather Station offers a digital display of temperature, wind speed, and wind direction (16-point display). Constructed of clear acrylic, the station kit includes 40 feet of cable, waterproof temperature sensor with 7-foot cable, power supply, and manual. Also available: the WILSEC Wind*Tech 1000 digital anemometer, a battery powered hand-held device with 5% accuracy. Not illustrated: the WILSEC Temp*Tech digital thermometer and WILSEC WS101C, which combines the WS100 sending unit with IBM-compatible software for recording and displaying weather data.

*WILSEC Weather Instruments, 104 Frost Avenue, Frostburg, MD 21532, (301) 689-9542. WS100 Station: $129.95 plus $3 shipping and handling; Wind*Tech 1000: $59.95 plus $3 shipping and handling; Temp*Tech: $27.95 plus $2 s & h; WS101C: $179.95 plus $3 s & h.*





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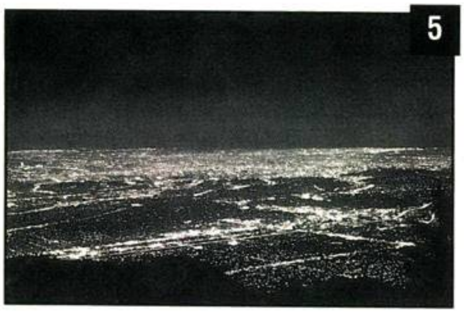
4

IL Photomultiplier System

The IL Photomultiplier System features high sensitivity, a side-viewing housing, and an IL1700 Research Radiometer with a direct reading digital display. It provides a 20 amps-cm^2/W sensitivity, which is 1,000 times greater than silicon detectors for measurements from 200 to 800 nm. The power supply features built-in rechargeable NiCad batteries for up to 8 hours of remote operation.

International Light, Inc., 17 Graf Road, Newburyport, MA 01950, (508) 462-0759. Starting at $3,420.

This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to the attention of Alan Dyer.



5 Light Pollution Slide Set

A slide and information set, *Light Pollution: Problems and Solutions,* produced in cooperation with the International Dark Sky Association, is available from the Astronomical Society of the Pacific. The 20-slide set illustrates the growth of light pollution with satellite images of the Earth and U.S. at night. The slides also include photos of ineffective lighting fixtures as well as more efficient designs. A 24-page booklet of nontechnical background information accompanies the slides.

Astronomical Society of the Pacific, Light Pollution Slide Orders, 390 Ashton Avenue, San Francisco, CA 94112; (415) 337-1100. $24.95 (includes postage and handling). Orders outside the U.S. please add $3.00 for postage and remit in U.S. funds; California orders please add sales tax.

6 Eyeball Solar Skreens

Roger Tuthill is making his safe Solar Skreen material available in 1- by 4-inch swatches for use as naked-eye solar filters. These pieces of aluminized mylar may be cut up and mounted in 35mm slide mounts. Astronomy clubs, planetariums, and other groups may purchase the solar filter swatches at quantity discounts for use in local fund-raising.

Roger W. Tuthill, Inc., Box 1086, Mountainside, NJ 07092-0086; (800) 223-1063. "Eyeball" solar filters: 10 or more, $2 each; 100 or more $1 each; 500 or more, $.75 each; 1,000 or more, $.60 each; 5,000 or more, $.50 each.

7 Leica "Ultra" Binoculars

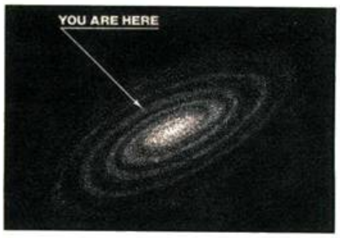
This line of binoculars features anti-reflective and phase-corrected coatings, a nitrogen-filled dustproof optical system, a waterproof (down to 16 feet) shock-absorbing body, extremely close focusing, and retractable eyecups for eyeglass wearers. The Ultra binoculars are available in 10x42, 8x42, and 7x42 models with and without rubber armoring.

Leica Camera Inc., 156 Ludlow Avenue, Northvale, NJ 07647, (201) 767-7500. Each model: $1,590.

8 Photo Stickers

A new print process allows the production of full-color peel-and-stick prints from your favorite 35mm astrophoto negative. Suitable for use on greeting cards, letters, and astrophoto logbooks, the photo stickers come in five sizes from $^{7}/_{8}$ by $1^{1}/_{16}$-inch to 3 $^{3}/_{16}$ by 4 $^{3}/_{4}$-inch.

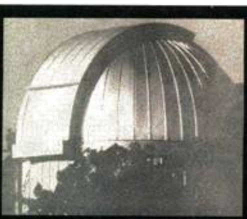
Pleiades Group, Suite 148 Dept. APR, 189 Berdan Avenue, Wayne, NJ 07470. $1^{1}/_{2}$ by 2 $^{1}/_{4}$-inch size: $14.95 plus $2.50 shipping and handling for sheet of 25.



9 Astronomy Products Support Free Light Pollution Brochures

Stars In Your Eyes, a group founded by Redmond, Oregon resident Harrell Graham, has launched a national campaign to combat light pollution. The group is selling T-shirts, posters, and postcards bearing the "You Are Here" artwork. Other designs are also available. Proceeds from the sale of these items are used to publish light pollution information brochures. Quantities of these brochures will be made available to clubs, groups, and individuals at no charge upon request. Write to:

Stars In Your Eyes, 6250 NW Atkinson, Redmond, OR 97756, (503) 548-8412. Postcards: 25 for $12; T-shirts: $13; Posters: $6. □



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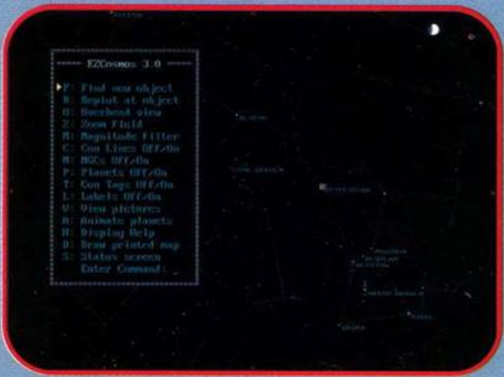
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Astronomy Books

BACK TO MARS: HOW AND WHY

Return to the Red Planet, by Eric Burgess, (Columbia University Press, 1990), ISBN 0-231-0692-1, 215 pages, sewn binding, acid-free paper, hardcover, $34.95.

We have been there before, but only with machines and in our imaginations. Now Eric Burgess tells how we may yet return to Mars, this time accompanying our machines. He also tells about our early knowledge of Mars, what we know now, and what we hope to learn when humans finally set foot on Mars.

This sibling planet has intrigued mankind for centuries. Burgess writes, "Man as a species seems to have an archetypal need to see himself reflected in the universe. . . . While holding on to a great desire not to be alone in the universe, he also fears that any other form of life will be inimical to him. Mars . . . played a very important role in satisfying this human need and focusing this human fear."

The first half of the book is an in-depth look at the Martian terrain. Using tables, text, and Mariner and Viking photos, Burgess takes you on a journey around Mars and explains the variety of its landscape. In this section, it would have been nice to include a map or atlas of Mars. Without either, the satellite photo-mosaics remain a fascinating but rather disjointed collection of surface features.

In the second half of the book, Burgess interestingly argues that life probably exists on Mars, but as micro-organisms deep underground. He examines the harsh environment of Antarctica and notes how similar some places on Mars are to our frozen southern continent. Life may have been existed (or may still today) in areas where there were shallow waters on Mars.

The last portion of the book takes you on several possible journeys to Mars. Dozens of scenarios exist and Burgess gives the pros and cons of each. Proposing ways to get to Mars is nothing new to him; he incorporated in this book some of his own possible methods and ideas first published in the early 1950s.

I found this book exciting and easy to read. It makes you want to get in line to be on the first trip. Except for the lack of a Mars atlas and the author's occasional tendency to repeat himself, I highly recommend this book for anyone interested in Mars or space exploration. — *Robert A. Garfinkle*

Observing

Zen and the Art of Photoelectric Photometry, by Jeffrey L. Hopkins, (HPO DeskTop Publishing, 1990), 152 pages, hardcover, $19.95 [address: 7812 W. Clayton Dr., Phoenix, AZ 85033-2934].

This is a detailed handbook and manual for any technically minded backyard astronomer interested in building a photoelectric photometer to measure star brightnesses precisely. It includes topics such as circuit diagrams, setting up an observing program, and ways of taking data. (It is the third edition of Hopkins' *Handbook for Photoelectric Photometry.*)

Variable Stars, by John E. Isles, (Enslow Publishers, 1990), ISBN 0-89490-208-3, 210 pages, paperback, $19.95.

Variable Stars is volume 8 in the series of deep-sky observing guides and handbooks published under the auspices of the Webb Society of the United Kingdom. This volume provides an overview of types of variable stars, explains how to observe them, and lists 110 variables for monitoring. Each has a small finder chart on which comparison stars are marked together with their magnitudes.

The Solar System

In the Stream of Stars, edited by William K. Hartmann, Andrei Sokolov, Ron Miller, and Vitaly Myagkov, (Workman Publishing, 1991), ISBN 0-89480-705-6, 183 pages, sewn binding, paperback, $19.95.

The artists always go there first. And now they're leading the way again, this time to places beyond the Moon. This book contains over 200 color paintings done by Soviet and Western space artists (the list includes ASTRONOMY's art director, Tom Hunt). To characterize the paintings broadly, you could say that Americans generally portray realistic scenes, while the Soviets are more attuned to emotional meanings. This is a rich harvest of thought- and dream-provoking works.

Introduction to the Solar System, by Jeffrey K. Wagner, (Saunders College Publishing, 1991), ISBN 0-03-051899-7, 600 pages approx., acid-free, recycled paper, hardcover, $46.75

This college astronomy textbook is aimed at non-science majors but differs from most in that it deals only with the solar system. Written at a level that any interested person could follow, it provides a systematic overview of each of the planets together with its rings and satellites. How up-to-date is it? Enough to include Voyager results from Neptune, but not Magellan radar images from Venus.

Comets, by Donald K. Yeomans, (John Wiley & Sons, 1991), ISBN 0-471-61011-9, 485 pages, hardcover, $35.00.

Subtitled "a chronological history of observation, science, myth, and folklore," this book begins with Greek writings on "long-haired stars," but dwells most on the period since the early 17th century. Halley's Comet gets full treatment and there is a 60-page appendix listing naked-eye comets up to 1700.

Planetary Mapping, edited by Ronald Greeley and Raymond M. Batson, (Cambridge University Press, 1990), ISBN 0-521-30774-0, 296 pages, hardcover, sewn-binding, $70.00.

Seven chapters and three appendices outline the remarkable state of solar-system mapping. Chapters explain topics such as choosing names of features, geologic mapping, surveying, and the history of extraterrestial mapping.

General Astronomy

Journeys to the Ends of the Universe, by C. R. Kitchin, (Adam Hilger, 1990), ISBN 0-7503-0037-X, 198 pages, sewn binding, hardcover, $30.00.

Eleven "journeys" — chapters — take the lay reader on a lively and entertaining tour of cosmology, stars, galaxies, planets, and sub-atomic particles.

America's Planetariums and Observatories, edited by R. L. Beck and Daryl Schrader, (Sunwest Space Systems, 1991), 200 pages approx., paperback, $12.95.

The core of this book is a set of descriptions of more than 80 planetariums and observatories in the United States. The descriptions, which average 2 pages (although the one on the U.S. Naval Observatory runs 12), were written by the institutions themselves and include information on their history, facilities, hours of operation, and so on.

Dictionary of Space Technology, by Mark Williamson, (Adam Hilger, 1990), ISBN 0-85274-339-4, 401 pages, hardcover, $50.

Written for the layman, this dictionary contains over 1,600 entries and 100 photos and diagrams; entries run about 50 to 100 words in length. At the back of the book is a classified list of dictionary entries. □

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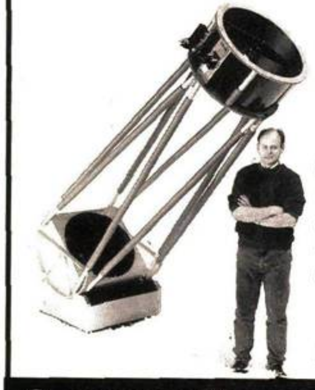

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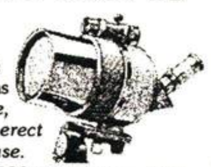

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Readings and Resources

Brightest Stars (page 30)

"Realm of the Hottest Stars" (February 1990), "The Coolest Stars" (May 1990), and "The Largest Stars in the Galaxy" (October 1990). Three ASTRONOMY articles that take varied looks at these stellar "superlatives."

Stars and Their Spectra, by James Kaler, (Cambridge University Press, 1989). A book for the interested lay reader that explores these types of stars (and others) in greater depth.

Dodge and Burn (page 68)

Color Printing Techniques, Eastman Kodak Co. Covers how to make prints and slides using Kodak equipment and chemicals, but much of the information applies to other brands of processing kits.

"The Joy of Color Printing" by Larry Myers, ASTRONOMY, November 1989. Introduces you to basic color printing in your own darkroom.

"Working Against the Grain of Fast Films" by Larry Myers, ASTRONOMY, February 1989. Describes a useful technique (multiple, or integration, printing) to reduce the visible grain from fast color negative films.

Star 1 CCD (page 73)

"First Look at a Fabulous CCD" by Richard Berry , ASTRONOMY, September 1990. A complete product review of the Star I CCD camera.

Spiral Arms (page 78)

Deep Sky Observing with Small Telescopes, by David J. Eicher and the editors of *Deep Sky,* (Enslow, 1989). A manual that includes data and amateur telescope observations for galaxies with spiral arms.

The Universe from Your Backyard, by David J. Eicher, (Cambridge University Press, 1988). A compilation of ASTRONOMY articles from the years 1983-1987 that includes a four-page section on galaxies in Ursa Major.

CREDITS

Cover: courtesy Phil James, University of Toledo, and NASA; *p. 4:* courtesy NRAO/AUI; *p. 22, left:* courtesy James Scotti, University of Arizona; *bottom:* Jane Luu and David Jewitt, University of Hawaii; *p. 24:* NASA/ESA; *p. 26, left:* NASA/ESA; *right:* COBE maps courtesy the COBE Science Working Group and Goddard Space Flight Center, NASA; *pp. 30-31:* painting by Robert Eggleton; *p. 32:* David Malin, Anglo-Australian Telescope Board, courtesy of the author; *p. 33:* spectra from the *Atlas of Representative Stellar Spectra* (Yamashita, Nariai, and Norimoto), courtesy of the author; *p. 34:* large photo from *An Atlas of the Milky Way* (Ross and Calvert), inset from European Southern Observatory Sky Survey, both courtesy of the author; *p. 35:* diagram by T. L. Hunt, spectrum from *International Ultraviolet Explorer Atlas of O-Type Spectra from 1200 to 1900 Å* (Walborn, Nichols-Bohlin, and Panek); *p. 36:* photo from Palomar Observatory, courtesy of the author; *p. 38:* NASA; *p. 39, top:* NASA; *bottom:* UIT instrument, at 160 nm wavelength, exposure of 291 seconds, false color added, Goddard Space Flight Center; *p. 40, top:* UIT instrument, at 155 nm wavelength, exposure of 1279 seconds, Goddard Space Flight Center; *bottom:* NASA; *p. 41, both:* NASA; *p. 42, top:* UIT instrument, at 220 nm wavelength, exposure of 640 seconds, Goddard Space Flight Center; *bottom:* 36-inch telescope, Kitt Peak National Observatory; *p. 43:* NASA; *pp. 44-45:* NASA images; *p. 47:* spectra courtesy Kenneth Carpenter; *p. 48, left:* NASA/ESA image; *right:* NASA image; *p. 54:* Jeff Myers, 210mm lens at f/3.8, Fuji 400 film, 1-second exposure on January 11, 1986; *p. 59:* Robert Provin and Brad Wallis, 6-inch f/5 reflector, Ektachrome 200 film pushed one stop, 10-minute exposure on October 28, 1978; *pp.62-63:* Lee C. Coombs, 6-inch refractor at f/25, Tech Pan film, 1/1000-second exposure, 94mm solar filter, June 15, 1989; *pp. 64-65:* Lee C. Coombs, 6-inch refractor at f/58, Tech Pan film, 1/125-second exposure, 94mm solar filter, March 17, 1989; *p. 64, sequence:* Rick Dilsizian, clockwise from top left: July 15, 1989; August 17, 1989; September 4, 1989; August 30, 1989; *p. 65, top:* diagram by Steve Davis; *p. 65, bottom:* Gregory Terrance, 7-inch refractor at f/53, Tech Pan film, 1/15-second exposure, September 4, 1989; *pp. 66-67:* diagrams by Steve Davis; *p. 66, middle:* John S. Hicks; *bottom:* Sacramento Peak Observatory; *p. 67:* NASA/NOAA Solar Observatory; *pp. 68-72:* all photos by Larry Myers; the Orion Nebula negative was taken with an 11-inch SCT on hypersensitized Konica 400 with a 40-minute exposure at f/6.3; all CCD photos by Richard Berry, 6-inch f/5 Newtonian reflector, exposure times varied between 30 seconds and 1,200 seconds as noted in the captions, all images were processed with IPLab™ software; *p. 78:* Richard W. Jakiel, 20-inch f/4.5 reflector at 175x; *p. 79:* Preston S. Justis, 10-inch f/6 reflector, hypered Tech Pan film, 50-minute exposure; *p. 80, top:* Gary Hug; *bottom left:* Preston S. Justis, 10-inch f/6 reflector, hypered Tech Pan film, 60-minute exposure; *bottom right:* Preston S. Justis, 10-inch f/6 reflector, hypered Tech Pan film, 65-minute exposure; *p. 81:* Richard W. Jakiel, 20-inch f/4.5 reflector at 175x; *p. 83, top:* Donald C. Parker, 16-inch reflector at f/76, Ektachrome 200 film, 6-second exposure on October 4, 1990; *middle:* Klaus Brasch, 14-inch SCT at f/200, Fujichrome 100 film, 2-second exposure on November 11, 1990; *bottom:* Gregory Terrance, 16-inch reflector at f/110 on January 8, 1991; *p. 84, top left:* Jeffrey L. Jones, 8-inch f/10 SCT, hypered Tech Pan film, 15-minute exposure, *bottom left:* David L. Coleman, 6-inch f/8 reflector, on November 9, 1985; *bottom right:* Bill and Sally Fletcher, 16-inch f/4.5 reflector, hypered Fujichrome Super HG 400 film, *p. 85:* Michael Stecker, 180mm f/2.5 lens, hypered Tech Pan film, 90-minute exposure with an H-alpha filter; *pp. G-1 through G-13 of Sky Guide:* Alan Dyer.

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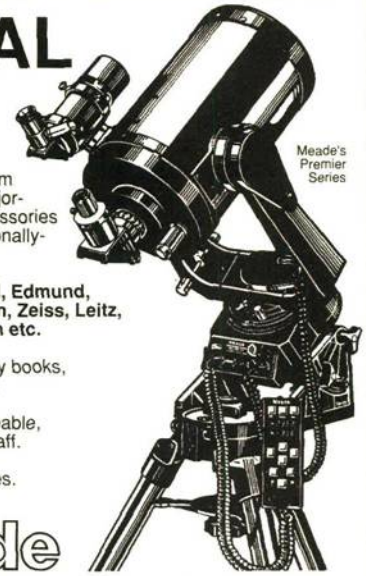

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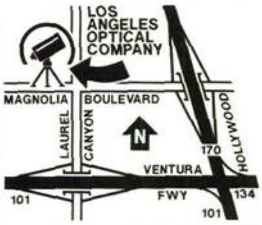

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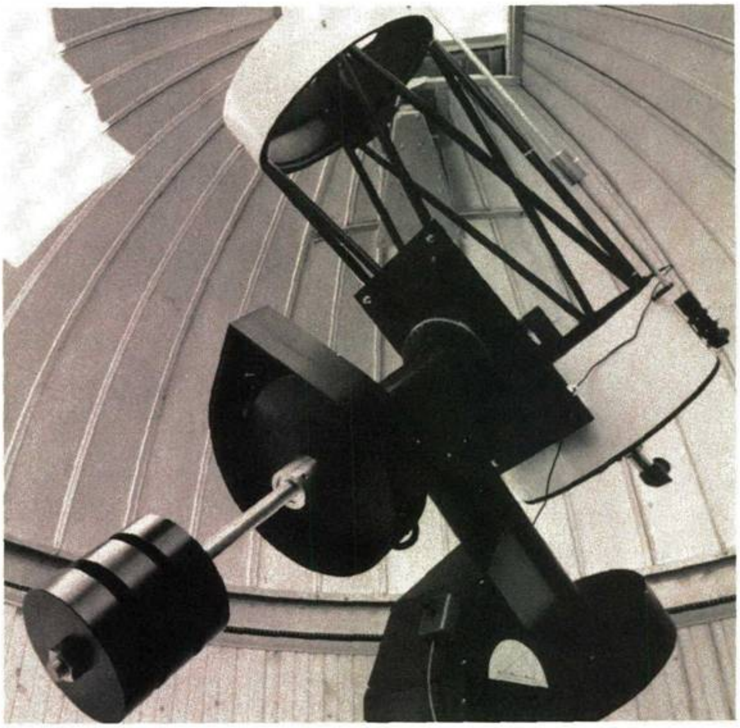

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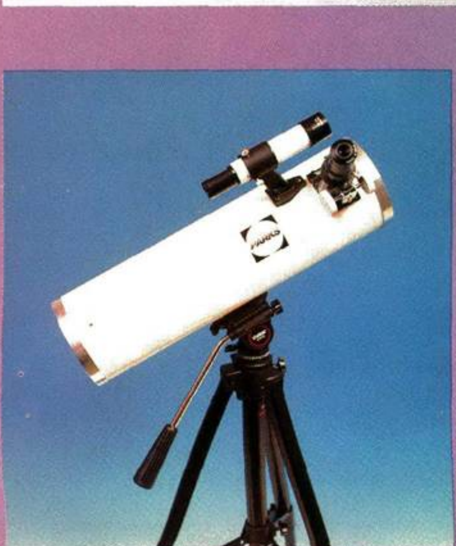

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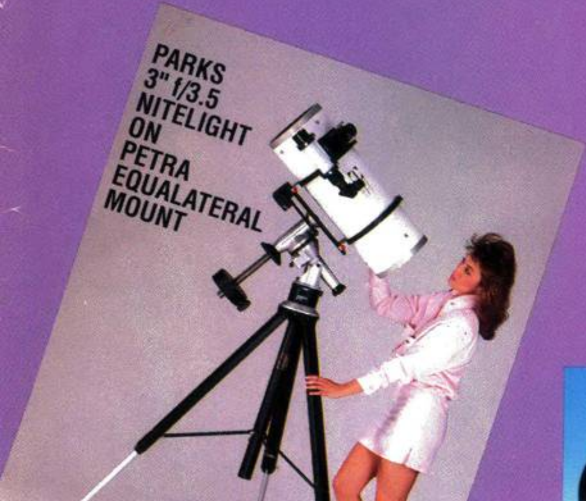

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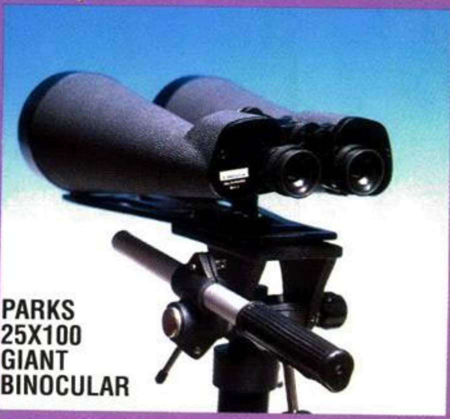

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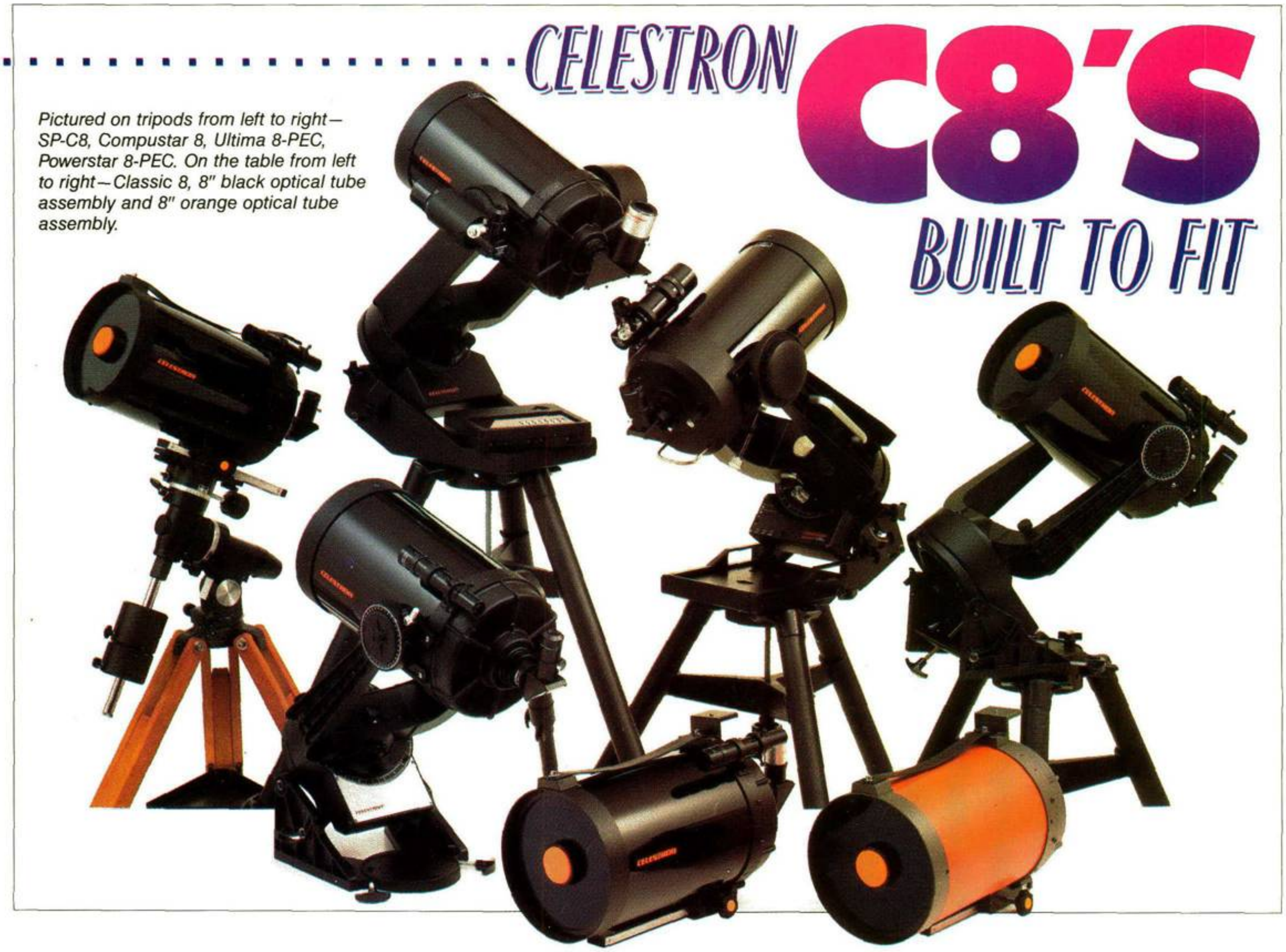

Pictured on tripods from left to right—SP-C8, Compustar 8, Ultima 8-PEC, Powerstar 8-PEC. On the table from left to right—Classic 8, 8″ black optical tube assembly and 8″ orange optical tube assembly.

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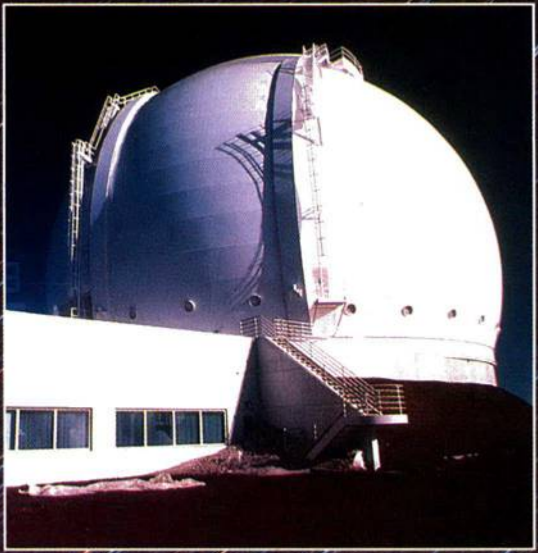
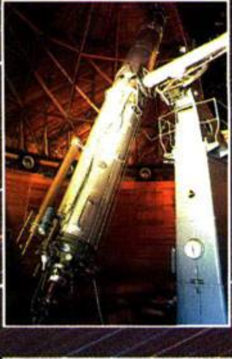
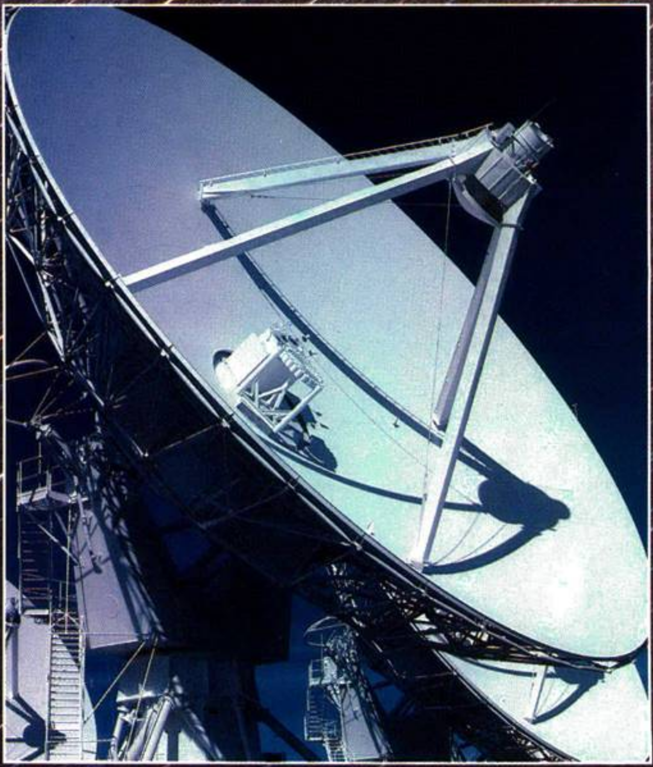
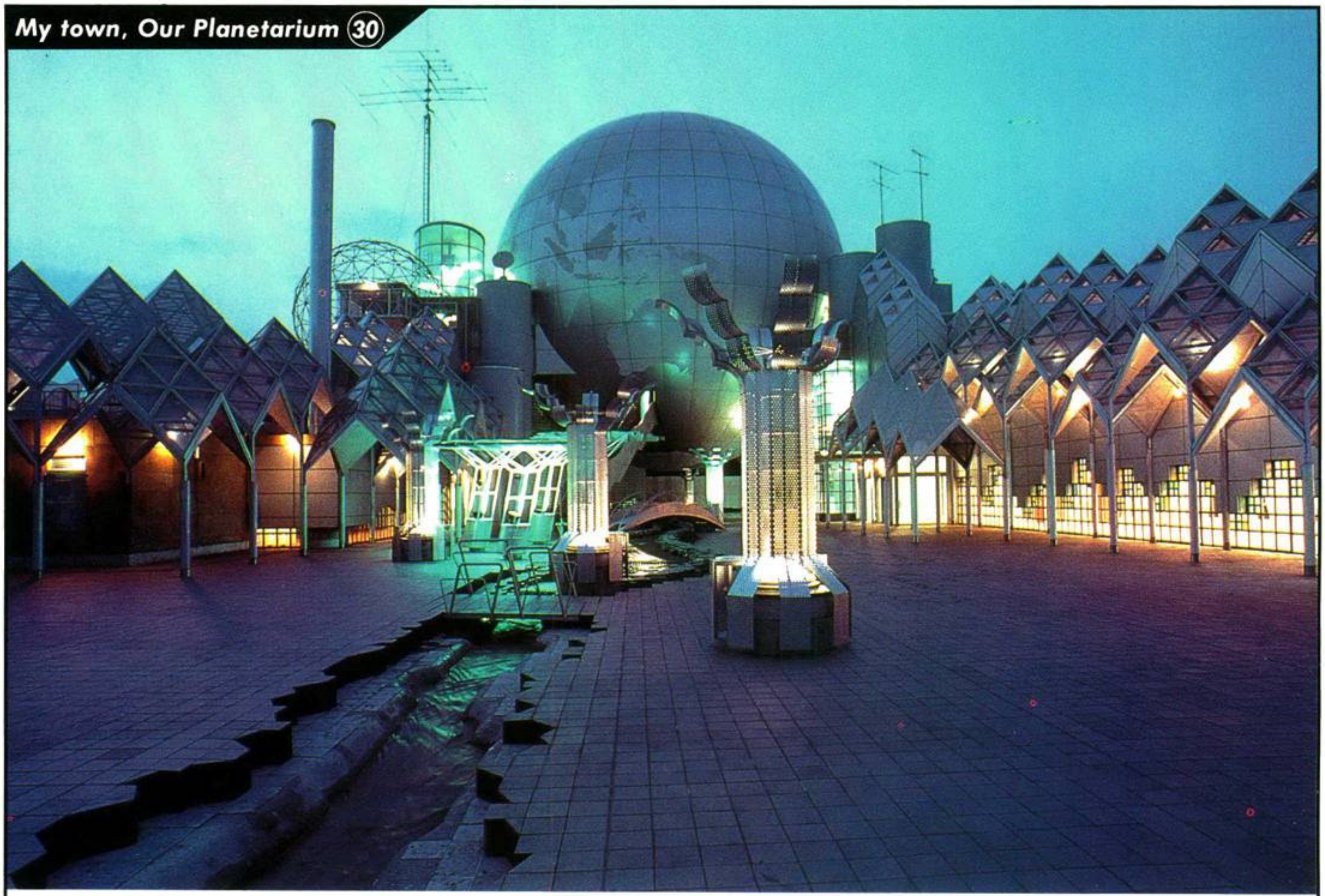






My town, Our Planetarium (30)



Welcome to Fairy Space: Shonandai Culture Center.

With its beautiful scenery of blue seas and green mountains, Fujisawa City is favored with natural splendor and a mild climate. Here, a cultural center for citizens was created utilizing a unique and up-to-date design. The name of this place is Shonandai Culture Center in Fujisawa City.

Many people have great expectations for this new and unconventional center. It has various installations, such as theaters, a public hall, citizen's center, and an exhibition hall.

These buildings are designed with a very modern feeling. For instance, there is a huge metal terrestrial globe or universal globe. In the children's pavilion there is a GOTO space simulator Model GSSII and Astrovision 70 so that children's romantic dreams of the universe can be brought to life. The planetarium seats 200. About 25,000 glittering stars are on the 20-meter dome which is inclined 30 degrees. Sit down and you'll be in space. While traveling freely through the solar system under a canopy of stars, you can watch the movements in space of various bodies and steep yourself in the night sky, past and future. Really, you are in the midst of the world of dreams.

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ASTRONOMY's
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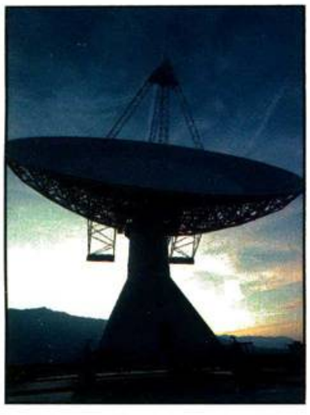
ACTIVITY GUIDE

Guide to Astronomy Clubs....G-03
Guide to Astronomy Events..G-10
Guide to Astronomy Places..G-12
Guide to Organizations.........G-18



Astronomy Clubs

Participating in astronomy club activities is a wonderful way to enhance your hobby. Even if you never officially join a club (although we'd encourage you do so!), you can still attend their Astronomy Day activities, star parties, public observing nights, instructional courses, or other events that clubs organize. During the summer and early autumn, many clubs hold public observing sessions at their club observatory, local planetarium, or a convenient park site. Some clubs have single big events, others have weekly or monthly observing sessions. Either way, they are great opportunities to meet and talk to fellow telescope owners and observers. Many a person has begun his or her lifelong interest in astronomy with just such a contact.

If your local club is not included on our list, please contact us so we can update our database. — *Alan Dyer*

ALABAMA

Auburn: Auburn Astronomical Society, 748 E. Magnolia Ave., 36830, Jim Chestnutt, (205) 821-1062. 20 members.

Birmingham: Birmingham Astronomical Society, P.O. Box 36311, 35236, Doug Finch, (205) 956-2818. Founded 1977, 130 members, Observatory (16" scope).

Huntsville: Von Braun Astronomical Society, Box 1142, 35807. Founded 1954, 158 members, Observatory with 21" Cassegrain. Public viewing nights.

Mobile: Mobile Astronomical Society, P.O. Box 169972, 36616-1972, Leland Cox, (205) 633-9079. Founded 1983, 25 members, Observatory with 12.5" reflector. Public viewing nights.

Rainbow City: Southside Astronomy Club, 103 Eddie Circle, 35901, Julian Long, (205) 442-7169.

Tuscumbia: Muscle Shoals Astronomical Society, 302 NE Commons, 35674, Homer Russell, Jr., (205) 383-6717.

ALASKA

Anchorage: Anchorage Astronomical Society, 3539 Dunkirk Dr., 99502, John Morrow, (907) 269-5744.

Fairbanks: Astronomical Units, Box 82210, 99708, Robert E. Fischer, (907) 456-6586. Founded 1986, 15 members, Observatory with 14" SCT.

AMERICAN SAMOA

Pago Pago: American Samoa Astronomical Society, P.O. Box 3076, 96799.

ARIZONA

Mesa: Leisure World Astronomers, 1792 Leisure World, 85206, Bud Ridley, (602) 981-3136.

Phoenix: Saguaro Astronomy Club, Paul Lind, (602) 863-3077. Founded 1977, 130 members.

Prescott: Prescott Astronomy Club, 1848 Emerald Dr., 86301.

Scottsdale: Phoenix Astronomical Society, 6945 East Gary Road, 85254, Raul V. Espinoza, (602) 996-3617.

Sierra Vista: Huachuca Astronomy Club, 11 E. Berridge Drive, 85635, Theodore Nelson, (602) 458-5973. Founded 1981, 20 members.

Sun City West: Astronomy Club of Sun City West, 17802 N. 131st Avenue, 85375, Jim Crisman, (602) 584-0896. Founded 1986, 140 members.

Tucson: Tucson Amateur Astronomy Association, 10385 Observatory Dr., 85747, Derald Nye. Founded 1954, 138 members.

ARKANSAS

Arkadelphia: Ark-La-Tex Skywatchers, P.O. Box 493, 71923, Rex McDaniel. Founded 1984, 26 members.

Dover: Arkansas Amateur Astronomers, 20 Rolling Green Dr., 72837, Rex McDaniel, (501) 968-8772. Observatory with 13" scope. Public viewing nights.

Fayetteville: Astronomical Society of NW Arkansas, 2503 Sweetbriar Dr., 72703.

Hackett: Arkansas-Oklahoma Astronomical Society, Coleman Memorial Observatory, P.O. Box 404, Route 1, 72937, (501) 474-4740. Founded 1985, 80 members. Hosts annual Arkansas Star Party.

Roland: Mid-South Astronomical Society, P.O. Box 38, 72135-0038, Bruce McMath, (501) 664-2662. Founded 1970, 35 members, Observatory (12.5" scope).

Texarkana: Red River Astronomy Club, 4808 Sunbury, 75502, Ken White, (501) 772-4200. Founded 1989.

CALIFORNIA

Aptos: Cabrillo Astronomical Stargazing Society, Cabrillo College, 6500 Soquel Dr., 95003. Founded 1985, 24 members. Monthly public star parties at Cabrillo College Observatory.

Arcata: Arcata Society for Amateur Astronomers, 3211 Alice Ave., 95521.

Bakersfield: Kern Astronomical Society, 4209 Tyndall Ave., 93313, David Hale.

Berkeley: Sidewalk Astronomers, P.O. Box 10003, 94709, Gerald Pardeilhan, (415) 527-4026.

Big Bear Lake: Bear Valley Astronomical Society, P.O. Box 874, 92314. Also the contact for Stony Ridge Observatory.

Chatsworth: Celestial Observers, 9534 Gierson Ave., 91311-4737, Michael Selden, (818) 882-6172. Founded 1972, 12 members.

Costa Mesa: Orange County Astronomers, 2195 Raleigh Ave., 92627, John Sanford, (714) 722-7900. Founded 1968, 610 members, Observatory with 22" Cassegrain.

Astronomy Clubs

Cucamonga: Pomona Valley Amateur Astronomers, 8773 Balsa Street, 91730, Bob Hibble, (714) 989-3680.

Eureka: Astronomers of Humboldt, P.O. Box 351, 95502, Robert Zigler, (707) 768-3296. Founded 1957, 25 members.

Fresno: Central Valley Astronomers, 5790 East Tarpey Ave., 93727, Clarence Funk, (209) 291-7879. Founded 1952, 52 members, 20" portable telescope. Monthly public star parties.

Hemet: Hemet Astronomical Society, 561 West Devonshire Ave., 92343, Ralph L. Shook, (714) 658-3631.

Idyllwild: Idyll-Gazers Amateur Astronomy Club, P.O. Box 1245, 92349, Joe Neu, (714) 659-3562. Monthly star parties until August.

Joshua Tree: Andromeda Astronomical Society, Star Route 1, P.O. Box 1112, 92252, Bill Crawford, Founded 1976, 30 members. Monthly star parties at Joshua Tree Nat'l Monument.

Lakewood: Excelsior Telescope Club, St. Pancratius Catholic Church, 3519 St. Pancratius Place, 90712, Fr. Ronald Royer, (213) 634-6111.

Lancaster: Antelope Valley Astronomical Society, P.O. Box 426, 93534, Steve Mathis, (805) 256-4261.

Los Angeles: Los Angeles Astronomical Society, 2800 East Observatory Road, 90027, Timothy Thompson, (213) 833-1733. Founded 1926, 350 members, Observatory with 31" reflector.

Mill Valley: Marin Stargazers, 27 Morning Sun, 94941.

Modesto: Stanislaus Amateur Astronomers, 1521 Clevenger Dr., 95356-0810, James Brockway, (209) 522-0082. Founded 1980, 50 members, Observatory with 30" scope. Public viewing nights.

Moraga: Astronomical Association of Northern California, 731 Camino Ricardo, 94556, Don Stone, (415) 376-3007.

Mountain View: Peninsula Astronomical Society, P.O. Box 4542, 94040, Bill Sorrells, (415) 566-3116.

Murrieta: Temecula Valley Astronomers, 37795 Sea Pines Court, 92362, Kent Smith, (714) 698-0975. Founded 1990, 15 members. Monthly star parties.

Newhall: Local Group of Santa Clarita Valley, 25032 Walnut St., 91321, LaVerne Booth, (805) 259-3284. Founded 1984, 60 members.

Oakland: Chabot Telescope Makers Workshop, 4917 Mountain Blvd., 94619.

Oakland: Eastbay Astronomical Society, 4917 Mountain Blvd., 94619.

Oceanside: Oceanside Photo & Telescope Astronomical Society, 929 Buena Rosa Court, Fallbrook, 92028, Penny Hauck, (619) 723-0684. Founded 1984, 170 members. Annual Star Party June 8 and 15.

Palm Desert: Astronomical Society of the Desert, College of the Desert, 43-500 Monterey Ave., 92260, Ashley McDermott, (619) 346-8041. Founded 1972, 88 members.

Pasadena: Mount Wilson Observatory Association, 813 Santa Barbara St., 91101.

Ramon: Tri-Valley Astronomers, 20 Cedar Point Loop, Apt. 213, 94583, Alan Gorski.

Ridgecrest: China Lake Astronomical Society, P.O. Box 1783, 93556.

Riverside: Riverside Astronomical Society, P.O. Box 51222, 92517-2222, 24-hour hotline: (714) 689-0116. Founded 1956, 100 members. Observatory.

Rocklin: Sacramento Valley Astronomical Society, P.O. Box 575, 95677, R. S. Marasso, (916) 624-3333.

San Bernardino: San Bernardino Amateur Astronomers, 1345 Garner Ave., 92411, David E. Garcia. Founded 1958, 70 members. Owns 24" Newtonian.

San Diego: San Diego Astronomy Association, P.O. Box 23215, 92193, Greg Cade, (619) 495-1787. Founded 1963, 310 members, Observatory with 22" scope. Public viewing nights.

San Diego: San Diego L5 Society, P.O. Box 4636, 92104, Albert Schafer, (619) 295-3690, 1,200 members.

San Francisco: S.T.A.R.S., City College of San Francisco, 50 Phelan Ave., 94112, (415) 239-3242. Founded 1969, 10 members, Observatory with 14" SCT. Student astronomy club.

San Francisco: San Francisco Amateur Astronomers, 114 Museum Way, 94114, Bob Levenson, (415) 468-3592. Founded 1952, 150 members, Observatory with 17.5" scope. Star parties on Mt. Tamalpais.

San Jose: San Jose Astronomical Association, 3509 Calico Ave., 95124, Jim Van Nuland, (408) 997-3347. Founded 1954, 300 members. Hosts monthly public star parties at Branham Lane City Park.

San Juan Bautista: Fremont Peak Observatory Association, P.O. Box 1110, 95045, Rick Morales, (408) 623-4255. Founded 1985, 175 members, Observatory with 30" reflector. Public observing on Sat. nights.

San Luis Obispo: Central Coast Astronomical Society, P.O. Box 1415, 93406, Lee Coombs, (805) 466-2788. Founded 1979, 60 members.

San Marcos: Astronomical Society of Southern California, P.O. Box 2046, 92069, Michael Wartenberg, (619) 741-6128.

San Mateo: San Mateo Astronomical Society, P.O. Box 974, Station A, 94403, Bob Bruynesteyn, (415) 349-3743. Founded 1960, 50 members.

Santa Barbara: Santa Barbara Astronomy Club, P.O. Box 3702, 93130, Clyde Kirkpatrick, (805) 966-3695. Founded 1957, 52 members, Observatory with 16.5" scope. Public viewing nights.

Santa Cruz: Santa Cruz Astronomy Club, L-2 San Carlos Lane, 95065, James M. Bricken, (408) 335-2450.

Santa Monica: Santa Monica Amateur Astronomy Club, 1415 Michigan Ave., 90404, Robert Lozano, (213) 450-1944. Founded 1981, 35 members.

Santa Rosa: Sonoma County Amateur Astronomers, P.O. Box 183, 95402, Ed Megill, (707) 795-7829. Founded 1975, 150 members. Observatory with 16" scope. Public viewing nights.

Simi Valley: Ventura County Astronomical Society, P.O. Box 982, 93062, Rick Williams, (805) 523-3066, 110 members.

Sonora: Omega-One, 21558 American River Dr., 95370, Lance Kearns, (209) 533-2260. Founded 1987, 30 members, Observatory with 13.1" scope. Public viewing nights.

Stockton: Stockton Astronomical Society, P.O. Box 243, 95201.

Tulare: Tulare Astronomical Association, P.O. Box 515, 93275, Stanley H. Manro, (209) 685-0585. Founded 1966, 100 members. Operates Arthur Pursell Observatory/Visitor Center.

Van Nuys: Los Angeles Valley College Astronomy Club, 5800 Fulton Ave., 91401, Bruce Dale, (818) 781-1200. Founded 1985, 30 members.

Vandenberg AFB: Vandenberg Amateur Astronomical Society, P.O. Box 5321, 93937, Steve Ball, (805) 733-2488. Founded 1985, 20 members, Observatory with 14" SCT. Public viewing nights every clear Fri. & Sat.

Walnut Creek: Mt. Diablo Astronomical Society, 1302 Roseann Dr., Martinez, 94553, Ginger Todd, (415) 229-3914. Founded 1958, 60 members. Monthly star parties at Mt. Diablo Summit.

Whittier: Western Observatorium, 14517 E. Broadway, 90604, Roger Wilcox, (213) 941-9755. Founded 1975, 40 members. Hosting annual Telescope Users Clinic Oct. 5.

Woodland Hills: Polaris Astronomical Association, 22018 Ybarra Road, 91364, Ray G. Coutchie, (818) 347-8922.

COLORADO

Colorado Springs: Colorado Springs Astronomical Society, P.O. Box 62022, 80962, Jim Lawrence, (719) 593-0801. Founded 1985, 50 members.

Colorado Springs: Rocky Mountain Astrophysical Group, 12815 Porcupine Lane, 80908, Paul Van Slyke, (719) 495-3828. Founded 1987, 100 members, Observatory with 32" scope. Public viewing nights.

Denver: Denver Astronomical Society, P.O. Box 10814, 80210, Dave Trott, (303) 871-5172. Founded 1947, 150 members, Observatory (20" Clark refractor).

Grand Junction: Western Colorado Astronomy Club, P.O. Box 55032, 81505, Harry Brauneis. Founded 1988, 40 members.

Longmont: Longmont Astronomical Society, 2944 Colgate Dr., 80501, James Wilson. 40 members.

Pueblo: Southern Colorado Astronomical Association, 2801 8th Ave., 81003, Mike Bosley. 6 members.

CONNECTICUT

New Haven: Astronomical Society of New Haven, P.O. Box 3005, 06515, Linda Rainey. Founded 1936, 74 members, Observatory with 10" scope. Monthly public star parties.

Oakdale: Thames Astronomical Society, 55 Doyle Road, 06370, Kathleen Audette, (203) 859-0071. Founded 1974, 23 members.

Stamford: Fairfield County Astronomical Society, Stamford Museum Observatory, 39 Scofieldtown Road, 06903, Charles Scovil, (203) 322-1648. Founded 1954, 76 members, Observatory with 22" Maksutov.

Stratford: Boothe Astronomical Society, 114 Kings College Place, 06497. 20 members.

Torrington: Litchfield Hills Amateur Astronomy Club, 361 Funston Ave., 06790, D. H. Wheeler, (203) 489-8898. Founded 1956, 21 members.

Waterbury: Mattatuck Astronomical Society, Mattatuck Community College, 750 Chase Parkway, 06708, J. Lawrence Pond, (203) 575-8236. Founded 1985, 78 members, Observatory with 14" SCT. Public viewing nights.

West Hartford: Astronomical Society of Greater Hartford, Gengras Planetarium, 950 Trout Brook Dr., 06119, Jay Sottolano, (203) 651-0096. Founded 1955, 160 members.

Westport: Westport Astronomical Society, P.O. Box 5118, 06880, 65 members.

DELAWARE

Wilmington: Delaware Astronomical Society, P.O. Box 652, 19899.

Wilmington: Mount Cuba Astronomical Observatory Inc., P.O. Box 3915, Hillside Hill Road, Greenville, 19807, Grace Quirk, (302) 654-6407. Founded 1958, 300 members, Observatory with 24" telescope. Public viewing nights.

FLORIDA

Bradenton: Local Group of Deep-Sky Observers, 2311 23rd Ave. West, 34205, Vic & Lynne Menard, (813) 747-8334. Founded 1983, 100 members.

Callahan: Callahan Astronomical Society, Route 3, Box 1062, 32011.

Cocoa: Brevard Astronomical Society, P.O. Box 1084, 32923, Tom Olsen, (407) 725-2451. Founded 1971, 30 members.

Fort Lauderdale: South Florida Amateur Astronomers Association, 16001 West State Rd. 84, 33326, Phil Hauger, (305) 721-4159. Founded 1966, 70 members. Public nights at Fox Observatory (12.5" scope) every 2nd and 4th Sat. each month.

Fort Pierce: Treasure Coast Astronomical Society, 131 Queen Catherina Court, 34949, Walter

Swentzell, (407) 465-4454. Founded 1983, 30 members. Monthly public star parties.

Ft. Myers: Southwest Florida Astronomical Society, P.O. Box 6583, Miracle Mile Station, 33911-6583, Manuel J. Mon, (813) 936-5669. Founded 1980, 50 members.

Jacksonville: Northeast Florida Astronomical Society, P.O. Box 16574, 32245-7338, Harold Carney, (904) 645-9310. Founded 1972, 50 members, Observatory (14.25" Newtonian-Cassegrain). Public viewing nights.

Largo: Tampa Area Astronomy Society, 9890 82nd St. N., 34647, John Novak, (813) 392-4699. Founded 1951, 45 members, Observatory with 20" reflector.

Melbourne: FIT Astronomy Society, Florida Institute of Technology, Physics Dept., 32901, Susan Shufelt, (407) 768-8000. 40 members, Observatory with 14" SCT.

Melbourne: Indian River Astronomical Society, 1201 Sunnypoint Dr., 32935.

Melrose: Alachua Astronomy Club, Rt. 2, Box 2915, 32666, Andrea Vann-Jenson, (904) 475-1014. Founded 1988, 28 members.

Miami: Belen Astronomy Club, 500 SW 127th Ave., 33134, Leo Nuñez, (305) 223-8600. Founded 1979, 30 members, Observatory with 10" scope.

Miami: Southern Cross Astronomical Society (Miami), 13841 SW 106 St., 33186, Robert Ward, (305) 385-5021. Founded 1922, 130 members, Observatory with 14" SCT. Public viewing nights.

Naples: Naples Astronomy Club, 5288 Sand Dollar Lane, 33940, John Marshall.

Orlando: Central Florida Astronomical Society, 810 East Rollins St., 32803, Doug Moningtan, (407) 896-7151. Founded 1955, 114 members.

Pensacola: Escambia Amateur Astronomers, 6235 Omie Circle, 32504-7625, J. Wayne Wooten, (904) 477-8859. Founded 1977, 180 members. Hosts sky interpretation programs at Ft. Pickens.

St. Augustine: Ancient City Astronomy Club, P.O. Box 546, 32085-0546, A.L. Ponjee, (904) 797-5704. Founded 1974, 25 members.

St. Petersburg: St. Petersburg Astronomy Club Inc., 594 59th St. South, 33707, Daniel W. Bricker, (813) 343-1594. Founded 1927, 140 members. Operates Hickory Hill Observing Complex.

Tampa: Museum Astronomy Resource Society (MARS), 2602 E. 98th Ave., 33612, Craig MacDougal, (813) 933-9617. Founded 1984, 35 members.

West Palm Beach: Astronomical Society of the Palm Beaches, South Florida Science Museum, 4801 Dreher Trail N., 33405, Gary M. Bogner, (407) 832-1988.

GEORGIA

Athens: Athens Astronomical Association, 160 Plantation Drive, 30605, Maurice E. Snook, (404) 543-3753. Founded 1977, 20 members.

Atlanta: Astronomical Society of the Atlantic, Center for High Angular Resolution Astronomy, Georgia State University, 30303, (404) 264-0451. Founded 1988, 220 members, Observatory with 30" scope. Public viewing nights.

Atlanta: Atlanta Astronomy Club Inc., P.O. Box 29631, 30359, Hal Crawford, (404) 320-9156. Founded 1947, 175 members, observatory with 20" scope. Public viewing nights. Hosting Summer Star Festival July 12-14.

Augusta: Astronomy Club of Augusta, P.O. Box 6373, 30916, Roger Venable, (404) 736-1740. Founded 1985, 35 members.

Macon: Middle Georgia Astronomical Society, Museum of Arts and Sciences, 4182 Forsyth Road, 31210, Gary L. Kretsinger, (912) 956-2145.

Savannah: Oglethorpe Astronomical Association, 4405 Paulsen St., 31405, Vickie Psillos, (912) 355-6705. Founded 1969, 17 members, Observatory (16" reflector).

HAWAII

Captain Cook: Mauna Kea Astronomical Society, 84-5095 Hawaii Belt Road, 96704, Howard Yamasaki, (808) 328-9201. Founded 1980, 80 members.

Honolulu: Hawaiian Astronomical Society, P.O. Box 17671, 96817, Mike Kaczmarski. Founded 1949, observatory with 12.5" scope. Public viewing nights.

Puunene: Maui Astronomy Club, P.O. Box 1168, 96784, Daniel O'Connell, (808) 878-3172.

IDAHO

Boise: Boise Astronomical Society, P.O. Box 8386, 83707. Founded 1982, 72 members.

Idaho Falls: Idaho Falls Astronomical Society, 1710 Claremont Lane, 83404, Jim Ruggiero, (208) 524-6317. Founded 1966, 15 members.

Pocatello: Pocatello Astronomical Society, 1543 Saratoga, 83201.

ILLINOIS

Batavia: Fox Valley Astronomical Society, P.O. Box 508, 60510, David Johnson, (708) 466-4811. Founded 1944, 45 members, Observatory with 16" Newtonian. Public viewing nights.

Chicago: Chicago Astronomical Society, P.O. Box 48504, 60648, Michael Barrett, (312) 725-5618. Founded 1862, 150 members.

Glenview: Skokie Valley Astronomers, 910 Glenwood Lane, 60025, Gretchen George, (312) 998-1627. Founded 1984, 22 members.

Jacksonville: Central Illinois Astronomical Association, Illinois College, 62650, Frederick Pilcher. Founded 1986, 10 members, Observatory (14" SCT). Public viewing nights.

Libertyville: Lake County Astronomical Society, 603 Dawes St., 60048, Jack Kramer, (708) 362-0959. Founded 1982, 70 members. Public viewing sessions at Lake County Museum.

Lisle: Illinois Benedictine College Astronomical Society, 5700 College Road, 60532-2099, Robert S. Buday, (312) 969-6550. Founded 1965, 15 members, Observatory with 16.5" Springfield scope.

Montgomery: Amateur Astronomers of Aurora, 69 Sheffield, 60538.

Mount Olive: Mount Olive Astronomical Society, 412 West 4th St. South, 62069.

Naperville: Naperville Astronomical Association, 205 N. Mill St., 60540, (708) 355-5357, Bob Crowley. Founded 1973, 81 members, Observatory (10" Newtonian). Public viewing nights.

Normal: Twin City Amateur Astronomers, P.O. Box 755, 61761-0755, Sharon MacDonald, (309) 827-4885. Founded 1960, 60 members.

Peoria: Peoria Astronomical Society, 1125 West Lake Ave., 61614, Charles Lamb, (309) 686-7000. Founded 1953, 120 members. Northmoor Observatory (9" refractor) & Jubilee Observatory (24" reflector). Public viewing nights.

Quincy: Quincy Astronomical Society, 1200 St. Charles Dr., 62301-7160, Kevin Clymer, (217) 222-6535. Founded 1981, 20 members, Observatory with 16" scope. Public viewing nights.

Rock Island: Popular Astronomy Club, John Deere Planetarium, Augustana College, 61201, Paul Castle, (309) 786-6119. Founded 1936, 56 members.

Rockford: Rockford Amateur Astronomers Inc., 6804 Alvina Road, 61101, Barry or Carol Bearman, (815) 962-6540. Founded 1958, 75 members. Public viewing 2nd & 4th Saturdays at Lockwood Park Observatory (10" refractor).

Schaumburg: Northwest Suburban Astronomers, 1417 Harvard Lane, 60193, Detlef Schmidt. Founded 1971, 120 members.

Springfield: Springfield Astronomy Society, 2224 S. 13th St., 62703, Don Walker.

St. Charles: Argonne Astronomy Club, 6N106 White Oak Lane, 60175, H. F. DaBoll, (312) 584-1162.

INDIANA

Evansville: Evansville Astronomical Society, P.O. Box 3474, 47733, Scott Conner, (812) 424-8639. Founded 1952, 55 members, Observatory with 14" scope. Public viewing nights.

Fort Wayne: Fort Wayne Astronomical Society, P.O. Box 6004, 46896, Greg O' Neill.

Hammond: Calumet Astronomical Soc., 2925 Cleveland St., 46323, Stephen Miller, (219) 845-9174. Founded 1975, 50 members. Observatory (16" Newtonian. Seasonal public star parties.

Mooresville: Indiana Astronomical Society, 2 Wilson Dr., 46158, J. Philip May, (317) 831-8387. Founded 1933, 150 members, Observatory with 36" scope.

South Bend: Michiana Astronomical Society, P.O. Box 262, 46624, John Greenlee, (219) 25508501. Founded 1974, 20 members.

Warsaw: Warsaw Astronomical Society, RR 8, Box 236, 46580, Jim Tague, (219) 269-1856.

West Lafayette: Wabash Valley Astronomical Society, 2634 Willow Drive, 47906, George Wyncott Jr., (317) 463-0271. Founded 1964, 25 members, Observatory with 14" SCT. Open houses 1st Sat. of the month at 7 p.m.

IOWA

Ames: Ames Area Amateur Astronomers, 1208 Wilson Ave., 50010, David Oesper, (515) 232-8705. Founded 1979, 77 members. Monthly public star parties at McFarland Park Observatory (12.5" scope).

Burlington: Southeastern Iowa Astronomy Club, 601 Walnut St., 52601, Jim Blair, (319) 753-2509. Founded 1984, 94 members, Observatory with 12" refractor. Monthly public nights.

Cedar Rapids: Cedar Amateur Astronomers, 1513 Parkwood Lane NE, 52402, Frank Olsen, (319) 393-5758. Founded 1979, 25 members.

Davenport: Quad Cities Astronomical Society, P.O. Box 3706, 52806, Wayne Jens, (319) 326-4995. Founded 1980, 45 members, Observatory with 20" scope. Public viewing nights.

Des Moines: Des Moines Astronomical Society, 2307 49th St., 50310-2538, C. L. Allen. Founded 1970, 35 members, Observatory with 16" scope. Public viewing nights.

KANSAS

Topeka: Northeast Kansas Amateur Astronomers League, P.O. Box 951, 66601, Mark Cunningham, (913) 271-5269. Founded 1978, 40 members.

Wichita: Kansas Astronomical Observers, P.O. Box 49013, 67201, Scott Fielding, (316) 838-5816. Founded 1977, 30 members. Hosting ALCON regional convention in June.

KENTUCKY

Fort Wright: Midwestern Astronomers, 1643 Elder Court, 41011.

Golden Pond: West Kentucky Amateur Astronomers, Land Between the Lakes, 42211-9001, Jim Boren, (615) 232-6820. Founded 1980, 20 members, Observatory with 12.5" reflector.

Lexington: Blue Grass Astronomical Society, 1016 Della Dr., 40504.

Louisville: Louisville Astronomical Society, P.O. Box 20742, 40450, Chuck Allen, (502) 228-3043. Founded 1933, 60 members, Observatory in planning stages. Public star parties.

LOUISIANA

Baton Rouge: Baton Rouge Astronomical Society Inc., 17324 Gains Mill Ave., 70817, (504) 291-1685. Founded 1981, 35 members.

Shreveport: Shreveport Astronomy Society, 353 Ockley Drive, 71105, Jennie Goodwin, (318) 865-2433. Founded 1959, 50 members. Observatory with 16" telescope).

Westwego: Pontchartrain Astronomy Society Inc., 948 Ave. E, 70094, Michael Sandras, (504) 340-0256. Founded 1959, 135 members, Observatory with 14" scope. Public viewing nights.

MAINE

Fairfield: Central Maine Astronomers, 4 Osburne St., 04937, John & Alison Meader, 14 members.

Glenburn: Penobscot Valley Star Gazers, c/o Jeff Churchill, Temple Dr., 04401, Todd Abbotts, (207) 947-3928. Founded 1990, 30 members.

Wells: Astronomical Society of Northern New England, P.O. Box 1238, 04090, Susan Gagne, 35 members.

MARYLAND

Arnold: Anne Arundel Association of Amateur Astronomers, Anne Arundel Community College, 101 College Parkway, 21012.

Astronomy Clubs

Baltimore: Baltimore Astronomical Soc., 601 Light St., 21230, (301) 685-2370. Founded 1881, 140 members, Observatory (8" Clark refractor). Public viewing nights.

Bel Air: Harford County Astronomical Society, P.O. Box 906, 21014, Richard Hagenston, (301) 836-4155. Founded 1970, 65 members, Observatory (16" scope. Monthly public viewing nights.

Bowie: Bowie Astronomical Society, 12700 Bridle Place, 20715, Fred Espenak.

Cumberland: Cumberland Astronomy Club, 350 Bedford St., 21502, G. Frank Simpson, (301) 722-7606. Founded 1964, 35 members.

Greenbelt: Goddard Astronomy Club, Goddard Space Flight Center, Code 440.8, 20771, George Gliba, (301) 345-4760. Founded 1961, 50 members, Observatory with 20" scope.

Greenbelt: National Capital Astronomers, 7006 Megan Lane, 20770, David & Joan Dunham. 258 members.

Hagerstown: Tri-State Astronomers, Washington County Planetarium, 823 Commonwealth Ave., 21740, Jim Taylor, (304) 274-1886. Founded 1985, 40 members. Star parties Fri. or Sat. nearest New Moon.

Westminster: Westminster Astronomical Society, 3481 Salem Bottom Road, 21157, Curtis Roelle, (301) 848-6384. Founded 1984, 70 members.

MASSACHUSETTS

Amherst: Amherst Area Amateur Astronomers Assn., 1403 South East St., 01002, Tom Whitney, (413) 256-6234. Founded 1984, 60 members, Observatory with 18" Clark refractor. Public viewing every clear Sat. night.

Boston: Amateur Telescope Makers of Boston, c/o 28 Taschereau Blvd., Nashua, New Hampshire, 03062, Marion Hochuli, (603) 888-0141. Founded 1934, 300 members.

Essex: North Shore Amateur Astronomy Club, P.O. Box 123, 01929, Michael D. McCoy, (508) 768-3494. Founded 1989, 27 members.

North Plymouth: Cape Cod Astronomical Society, P.O. Box 1170, 02556, Michael Petrasko, (508) 563-6045. Founded 1985, 59 members.

Norwell: South Shore Astronomical Society, P.O. Box 429, Jacobs Lane, 02061, *Rolf Egon*, (617) 337-2572. Founded 1958, 55 members, Observatory (10" Cassegrain). Public viewing nights.

Rutland: Aldrich Astronomical Society, 7 Cheryl Ann Dr., 01543, Russell A. Chaplis, (508) 886-6777. Founded 1948, 35 members, Observatory (12.5" scope).

West Springfield: Springfield Stars Club, 107 Lower Beverly Hills, 01089, John E. Welch, (413) 734-9179. Founded 1948, 75 members, Observatory with 20" SCT. Public viewing nights.

MICHIGAN

Adrian: Astronomical Society of Lenawee County, Box 229, Hudson, 49247, Jim Whitehouse, (517) 448-7173. Founded 1990, 12 members.

Alpena: Huron Amateur Astronomers, 4963 Truckey Road, 49707, Jim Bruton. 14 members.

Brighton: Friends United Through Astronomy, 8191 Woodland Shore, Lot #12, 48116, Gary Anderson, (313) 227-9347. Founded 1982.

Detroit: Detroit Astronomical Society, 14298 Lauder Avenue, 48219, Jack Brisbin, (313) 981-4096. Founded 1932, 60 members. Skywatchers Hotline (313) 837-0130.

East Detroit: Warren Astronomical Society, P.O. Box 474, 48021. Founded 1961, 90 members, Observatory with 12.5" scope.

East Lansing: Capital Area Astronomy Club, Abrams Planetarium, Michigan State University, 48824, David Batch, (517) 355-4676, 50 members.

Hillsdale: Astronomical Soc. of Hillsdale, 500 N. Dunes Road, 49242, Pat Calligan, (517) 439-1295. Founded 1985, 20 members.

Holland: Shoreline Amateur Astronomy Association, A-4679 46th, 49423, Mark Hogsden, 15 members.

Kalamazoo: Kalamazoo Astronomical Society, Kalamazoo Public Museum, 315 South Rose Street, 49007, Eric Schreur, (616) 345-7092. Founded 1936, 20 members.

Lowell: Grand Rapids Amateur Astronomical Association, 3308 Kissing Rock Road SE, 49331, Evelyn Marron, (616) 897-7065, Observatory with 17" Newtonian & 6" refractor open 2nd Sat. & last Fri. of each month.

Marquette: Marquette Astronomical Society, P.O. Box 761, 49855, Brian Halbrook, (906) 228-6351. Founded 1974, 25 members, Observatory with 8" scope. Public viewing nights.

Midland: Sunset Astronomical Society, 4300 Washington, 48640, Bill Albe, (517) 835-4142. Founded 1974, 30 members, Observatory with 16" SCT. Public viewing nights.

Muskegon: Muskegon Astronomical Society, P.O. Box 363, 49443, Dale Johnson, (616) 798-7680. Founded 1970, 35 members, Observatory with 12.5" reflector. Public viewing nights.

Petersburg: Toledo Astronomical Association, 8534 Covert Road, 49270, Courtney Earhart, (313) 856-6204. Founded 1975, 35 members, Observatory with 25" Newtonian.

Plymouth: Astronomical Society of Michigan, 11422 Waverly, 48170, Michael Best, (313) 459-2378. Founded 1985, 198 members.

Sturgis: Sturgis Astronomy Group, 302 Virginia, 49091, Philip Thrasher, (616) 651-8176. Founded 1957, 6 members.

Traverse City: Grand Traverse Astronomical Society, 5999 Secor, 49684, Jerry Dobek, (616) 922-1260. Founded 1982, 32 members, Observatory with 14" SCT.

MINNESOTA

Afton: 3-M Astronomical Society, 14601 55th St. South, 55001.

Brainerd: North Star Astronomy Club, 606 South 8th St., 56401, David Starkka, (218) 829-4029. Founded 1982, 25 members.

Duluth: Arrowhead Astronomical Society, Alworth Planetarium, of Minnesota-Duluth, 55812, Glenn Langhorst, (218) 726-7129. Founded 1979, 30 members. Hosting Northern Nights '90, free day of astronomy activities and viewing, Sept. 7.

New Ulm: Minnesota Valley Amateur Astronomers, Route 4, Box 15A, 56073, Roger Dier, (507) 359-2488. Founded 1986, 20 members.

St. Paul: Minnesota Astronomical Society, 30 East 10th St., 55101, Max Radloff, (612) 643-4092. Founded 1973, 170 members. Bi-monthly star parties.

MISSISSIPPI

French Camp: Rainwater Astronomical Association, French Camp Academy, 39745, James Hill, (601) 547-6970. 45 members, Observatory with 13 instruments including 21" reflector.

Jackson: Jackson Astronomical Association, 6207 Winthrop Circle, 39206, Walter Rebmann, (601) 982-2317. Founded 1974, 36 members, Observatory with 13" scope.

MISSOURI

Blue Springs: Astronomical Society of Kansas City, P.O. Box 400, 64013, Gary Pittman, (816) 228-4238. Founded 1936, 180 members, Observatory with 30" scope. Public viewing nights.

Columbia: Central Missouri Amateur Astronomers, 261 Stardust Lane, 65201.

Dawn: North Central Missouri Amateur Astronomers, Rt. 1 Box 111, 64638, Jim Jones, 10 members.

Florissant: McDonnell Douglas Amateur Astronomy Club, 3491 Heather Trail Dr., 63031, Richard Melvin, (314) 569-4773.

Fort Leonard Wood: Ozarks Telescope Makers & Amateur Astronomers, 29 Williams St., 65473, Peter Bessenbruch, (314) 329-3344. Founded 1987, 45 members. Hosts annual Ozarks Star Party.

Hannibal: Mark Twain Astronomical Society, 45 Pioneer Trail, 63401, William J. Remillong.

Hazelwood: Rural Astronomers of Missouri, 209C Chapel Ridge, 63042.

Riverside: Prairie View Astronomical Society, 931 NW Valley Lane, 64150.

St. Louis: St. Louis Astronomical Society, Route 1, Box 176-A, Silex, 63377, Tom Butler. 264 members.

NEW HAMPSHIRE

Claremont: Springfield Telescope Makers, Chapel Grove, Box 434, 03734, Norman Fredrick, (603) 542-2928.

Keene: Keene Amateur Astronomers Inc., 131 Carroll St., 03431, Paul Fisher, (603) 352-6393. Founded 1950, 35 members, Observatory with 13.1" telescope.

Penacook: New Hampshire Astronomical Society, 22 Center St., 03303, Nelson D. LaClair, (603) 753-9225. 30 members.

NEW JERSEY

Boonton: Sheep Hill Astronomical Association, P.O. Box 111, 07005, Evert Bono, (201) 335-5990. 45 members, observatory with 16" Newtonian. Monthly public viewing nights.

Clifton: North Jersey Astronomical Group, P.O. Box 4021, Allwood Station, 07012, Grace Casalino, (201) 345-STAR. Founded 1981, 60 members, Observatory with 14" SCT. Bi-weekly public nights.

Cranford: Amateur Astronomers Inc., William Miller Sperry Observatory, 1033 Springfield Ave., 07016, George Chaplenko, (908) 709-7520. Founded 1949, 380 members, Observatory with 24" scope. Public viewing nights. Call (908) 276-STAR.

East Hanover: Morris Museum Astronomical Society, 6 Deforest Avenue, 07936, Ronald Russo, 201-386-1848. Founded 1973, 70 members. 16" Newtonian telescope & 8" SCT.

Glassboro: Tychonian Observers, Glassboro State College, Dept. of Physical Science, 08028, W. C. Woods, Jr., (609) 863-7348. Founded 1962, 20 members, Observatory with 6" scope.

High Bridge: New Jersey Astronomical Association, P.O. Box 214, 08829, Ben Cavotta, (201) 638-8500. Founded 1965, 178 members, Observatory with 26" scope.

Holmdel: STAR Astronomy Society, P.O. Box 547, 07733, Doug Krampert. Founded 1957, 50 members.

Jamesburg: Concordia Astronomy Club, P.O. Box 22, 08831-0022, Eli Drapkin, (609) 655-1422. Founded 1988, 120 members.

Orange: Montclair Telescope Club Inc., P.O. Box 704, 07050, Roger Salles, (201) 672-2223. Founded 1955, 30 members.

Princeton: Amateur Astronomers Association of Princeton, P.O. Box 2017, 08540, Greg Mauro, (609) 585-9465. Founded 1973, 85 members, Observatory with 12.5" Newtonian & 6" refractor. Public viewing nights.

Toms River: Astronomical Society of the Toms River Area (ASTRA), Novins Planetarium, Ocean County College, 08754-2001, Erik Zimmerman, (201) 255-0343. Founded 1977, 60 members. Public star party July 12 at Novins Planetarium.

Williamstown: Willingboro Astronomical Society, RD 8, Box

362-A, 08094, Jack Koch, (609) 629-0180. Founded 1957, 35 members, Observatory with 14" reflector.

NEW MEXICO

Alamogordo: Alamogordo Amateur Astronomers, 1210 Filipino, 88310, Paula Hamilton, (505) 434-0115.

Albuquerque: Albuquerque Astronomical Society, P.O. Box 54072, 87153, Bruce Levin, (505) 299-0891. Founded 1958, 250 members.

Clovis: Clovis Astronomy Club, 216 Sandzen, 88101.

Hobbs: Lea County Astronomical Society, NMJC Science Building, 5317 Lovington Highway, 88240, V.G. Berner, (505) 392-4510. Founded 1977, 20 members.

Las Cruces: Astronomical Society of Las Cruces, P.O. Box 921, 88004.

NEW YORK

Bellmore: Astronomical Society of Long Island, 801 Oak St., 11710, Alan Buckley, (516) 221-5914. Founded 1960, 100 members.

Buffalo: Buffalo Astronomical Association Inc., Buffalo Museum of Science, Humboldt Parkway, 14211, Doris Koestler, (716) 683-2970. Founded 1937, 110 members.

Clinton: Mohawk Valley Astronomical Society, Box 674-B, Hamilton College, 13323, Richard Somer, (315) 859-4122. Founded 1989, 120 members, Observatory (11" Maksutov). Monthly star parties.

Corning: Elmira-Corning Astronomical Society, 17 West Hazel St., 14830, Marilyn L. O'Connell, (607) 962-5435. Founded 1960, 60 members.

Dewitt: Syracuse Astronomical Society Inc., 150 Terrace View Road, 13214, Gershon Blackmore, (315) 446-7167. Founded 1964, 100 members, Observatory with 16" Newtonian.

Frewsburg: Marshal Martz Memorial Astronomical Assoc., 176 Robin Hill Road, 14738, Tom Bemus, (716) 386-4566. Founded 1979, 75 members, Observatory with 30" Newtonian.

Getzville: Association of Observational Astronomers of Western New York, 1955 Hopkins Road, 14068, Carl Milazzo, (716) 688-4869. Founded 1989, 65 members.

Huntington: Long Island Astronomy Club, 3 Colby Court, Dix Hills, 11746, Richard Pluschau, (516) 499-6599. Founded 1991, 5 members.

Lake Placid: Tri-Lakes Astronomical Society, 100 Sentinel Road, 12946, George R. Viscome. Founded 1986, 15 members.

Lindenhurst: Amateur Observers' Society of New York, 707 South 9th St., 11757, Eric Barnes, (516) 957-3713. Founded 1965, 52 members.

Lockport: Lockport Astronomy Association, 7053 Northview Dr., 14094, Richard Lahrs, (716) 433-4706. Founded 1966, 25 members, Observatory (12" scope). Public viewing every Wed. night.

Mahopac: Putnam County Astronomy Club, Steve Rochlitz, P.O. Box 737, 10541.

New York: Amateur Astronomers Association of New York Inc., 1010 Park Ave., 10028, John Marshall, (212) 535-2922. Founded 1929, 550 members, Observatory. Hosts monthly public star parties in New York area.

Pearl River: Rockland Astronomy Club, 110 Pascack Ave., 10965, Allan Green, (914) 735-7303. Founded 1970, 245 members. Hosts monthly star parties at Harriman State Park.

Rochester: RIT Astronomy Club, Rochester Institute of Technology, Dept. of Physics 08, 14623. Founded 1989, 30 members.

Rochester: Rochester Academy of Science Astronomy Club, 105 Wyandover Road, 14616, David Smith, (716) 621-7593.

Schenectady: Albany Area Amateur Astronomers, 1529 Valencia Road, 12309, Bob Mulford, (518) 374-8744. Founded 1949, 50 members, Observatory with 18" Dobson.

Southold: Custer Institute Astronomy Club, P.O. Box 1204, Main Bayview Road, 11971, Barbara Lebkuecher, (516) 722-3073. Founded 1978, 130 members, Observatory with 5" Clark refractor. Hosting Astronomy Jamboree Oct. 4-6.

Staten Island: Astronomical Society of New York City, 153 Arlo Road, 10301, T. W. Hamilton, (718) 727-1967.

Staten Island: Wagner College Astronomy Club, 631 Howard Ave., 10301, Paul Albicocco, (317) 390-3341.

Vestal: Kopernik Astronomical Society, Kopernik Observatory, Underwood Road, 13850, Jay Edwards, (607) 748-3685. Founded 1970, 150 members, Observatory with 14" scope. Public viewing nights.

Watertown: Northern New York Astronomical Society, P.O. Box 106, 13601, Pete Beaumont, (315) 788-2472.

Yonkers: Westchester Astronomy Club, Andrus Planetarium Observatory, 511 Warburton Ave., 10701, (914) 963-4550.

NEBRASKA

Lincoln: Prairie Astronomy Club, P.O. Box 80553, 68501, Lee Thomas, (402) 483-5639. Founded 1965, 70 members, Observatory with 14" SCT. Public viewing nights.

Omaha: Omaha Astronomical Society, 5025 S 163 St., 68135, Bill Jacobsen. 89 members.

NEVADA

Elko: Elko Astronomical Society, 550 South 12th #22, 89801, Len Seymour, (702) 738-7916. Founded 1987, 20 members.

Las Vegas: Las Vegas Astronomical Society, Clark County Community College, 3200 East Cheyenne Ave., 89030, John Ruff, (702) 459-8401. Founded 1980, 125 members.

Reno: Astronomical Society of Nevada, 825 Wilkinson Avenue, 89502, Italo Gavazzi, (702) 329-9946.

NORTH CAROLINA

Albemarle: Stanly County Astronomical Society, P.O. Box 1269, 28001, Herbert Hartley, (704) 982-3728. Founded 1985, 15 members. Hosts monthly star parties at Morrow Mountain State Park.

Asheville: Starfax Assoc., P.O. Box 6084, 28816, Timothy Jordan. Founded 1981, 40 members.

Castle Hayne: Cape Fear Astronomy Club, 110 Linville Dr., 28429, Paul Petty, (919) 675-2952. Founded 1983, 30 members.

Fayetteville: Astronomy Club of Cumberland County, 2308 Colgate Dr., 28304, Allen Faircloth, (919) 485-8515. Founded 1983, 17 members.

Gastonia: Gaston Astronomy Club, P.O. Box 953, 28054, Larry Benefield, (704) 825-5341.

Goldsboro: Eastern Carolina Astronomy Club, 1607 Munroe Lane, 27543, Robert Krieger, (919) 778-3377. Founded 1988, 35 members.

Granite Falls: Catawba Valley Astronomy Club, Rt. 3, Box 472, 28630, Greg Kirby, (704) 396-7656. Founded 1976, 55 members.

Greensboro: Greensboro Astronomy Club, The Natural Science Center, 4301 Lawndale Dr., 27408. Founded 1949, 50 members. Public star parties at Hagan-Stone Park.

Matthews: Charlotte Amateur Astronomers Club, 245 Timber Lane, 28105, Gayle Riggsbee, (704) 846-3136. Founded 1954, 100 members, Observatory with 17.5" scope. Public viewing nights.

Raleigh: Raleigh Astronomy Club, P.O. Box 10643, 27605, Mark Lang, (919) 460-7900. Founded 1977, 65 members. Observatory with 24" scope.

Salisbury: Astronomical Society of Rowan County, Margaret Woodson Planetarium, 1636 Parkview Circle, 28144, Ellen Trexler, (704) 636-3462.

Statesville: Piedmont Amateur Astronomers, Route 2, P.O. Box 181, Troutman, 28116, Ronnie Sherril, (704) 528-9316. Founded 1988, 26 members.

Trinity: Thomasville Area Astronomy Club, Route 3, Box 273, 27370, Arthur Oates, (919) 431-5062. Founded 1986, 30 members.

Winston-Salem: Forsyth Astronomical Society, 504 Gayron Drive, 27105, Stan Griffin, (919) 744-7141.

NORTH DAKOTA

Bismarck: Dakota Astronomical Society, P.O. Box 2539, 58502-2539, John R. Wetsch, (701) 256-3620. Founded 1987, 50 members.

Fargo: Moorhead-Fargo Astronomical Society, 1420 8th St. S., 58103, Robert Brummond. Founded 1970, 16 members.

OHIO

Akron: Astronomy Club of Akron, 1630 Thornapple Ave., 44301, Mark Kochheiser, (216) 724-7761. Founded 1949, 120 members, Observatory with 12.5" scope. Public viewing nights.

Chagrin Falls: Chagrin Valley Astronomical Society, P.O. Box 11, 44022, Don Himes, (216) 247-5114. Founded 1963, 20 members, Observatory with 16" telescope. Public viewing nights.

Cincinnati: Cincinnati Astronomical Society, 5497 Washigo Dr., 45230, 154 members.

Cleveland: Cuyahoga Astronomical Association, P.O. Box 29089, 44129-0089, Dawn Jenkins, (216) 521-5115. Founded 1959, 80 members.

Cleveland: Lewis Astronomy Club, 21000 Brookpark Road, M.S. 16-1, 44135, Martin Mayer, (216) 433-8451. Founded 1980, 10 members.

Columbus: Columbus Astronomical Soc., 5280 Cape Cod Ln., 43235, Tom Burns, (614) 459-7742. Founded 1948, 200 members.

Dayton: Miami Valley Astronomical Society, 2629 Ridge Ave., 45414, Wade E. Allen, (513) 275-7431. 66 members.

Kenton: Lima Astronomy Club Inc., 811 Brice Ave., 45801, Joanne Konst.

Lima: Lima Astronomy Club, P.O. Box 201, 45801, (419) 422-8313. Operates Schoonover Observatory. Public viewing nights.

Lorain: Black River Astronomical Society, 1631 Maple Drive., 44052, Michael Harkey, (216) 288-8556. Founded 1948, 50 members.

Mansfield: Richland Astronomical Society, P.O. Box 1118, 44901, Keith Moore, (419) 468-3542. Founded 1960, 38 members, Observatory with 31" Newtonian. Open House first Sat. each month.

New Philadelphia: Tucawaras County Amateur Astronomical Society, 1315 E. High Ave., 44663.

Newton Falls: Mahoning Valley Astronomical Society, 1074 SR534 NW, 44444, Edwin Bishop, (216) 742-3616. Founded 1938, 30 members, Observatory with 16" scope. Public viewing nights.

Ravenna: Kent Quadrangle Astronomical Society, 7353 State Route 14, Lot 12, 44266.

Rossford: Northwest Ohio Visual Astronomers, 1018 E. Elmtree Road, 43460, Frank Myers, (419) 666-8566. Founded 1990, 12 members.

South Point: Ohio Valley Astronomical Soc., Rt. 6, Box 350, 45680, Scott Hogsten. 13 members.

Tiffin: Sandusky Valley Amateur Astronomy Club, 650 S. Washington St., 44883, Keith Moore. 22 members.

Troy: Stillwater Stargazers, Brukner Nature Center, 5995 Horseshoe Bend Rd., 45373, (513) 698-6494. Founded 1985, 20 members.. Public star parties.

Wilmot: Wilderness Center Astronomy Club, P.O. Box 202, 44689, Dave Gill, (216) 833-9399. Founded 1983, 45 members.

OKLAHOMA

Ardmore: Arbuckle Astronomical Society, 713 Ash NW, 73401, Steve Girard, (405) 226-0339. Founded 1985, 27 members.

Bartlesville: Bartlesville Astronomical Society, 225 SE Fenway Place, 74006, Ken Willcox, (918) 333-1966. Founded 1958, 20 members. Owns a 12.5" Newtonian.

Boise City: Cimarron County Star Gazers, P.O. Box 278, 73933, Jim Rosebery, (405) 544-2222.

Enid: Northwest Oklahoma Astronomy Society, 1719 Pawnee, 73703, Dan Mathews, (405) 233-5707. Founded 1978, 50 members.

Oklahoma City: Oklahoma City Astronomy Club, P.O. Box 21221, 73156, Wayne Wyrick, (405) 424-5545. Founded 1958, 75 members, Observatory with 12.5" scope.

Astronomy Clubs

Purcell: Central Oklahoma Astronomy Club, P.O. Box 628, 73080.

Sallisaw: Sallisaw Amateur Telescope Club, 109 South Cedar, 74955, Bob Moody, (918) 775-3739.

Tulsa: Astronomy Club of Tulsa, 3832 S. Victor Ave., 74105, Newell Pottorf, (918) 742-7577. Founded 1937, 105 members, Observatory with 16" scope. Public viewing nights.

OREGON

Bend: Central Oregon Astronomical Society, 17081 Cooper Drive, 97707.

Eugene: Eugene Astronomical Society, Lane ESD Planetarium, P.O. Box 2680, 97402, Cuyla Shelton, (503) 345-7748. Founded 1959, 80 members.

Portland: Rose City Astronomers, Oregon Museum of Science and Industry, 4015 S.W. Canyon Road, 97221, Dale Fenske, (503) 256-1840. Founded 1890, 120 members.

Roseburg: Umpqua Amateur Astronomers, Umpqua Community College, 3150 West Military Avenue, 97470, Paul Morgan, (503) 673-1081. Founded 1987, 20 members.

Veronia: Northwest Astronomy Group, 55371 McDonald Road, 97064, Sandy Mikalow, (503) 429-2430. Founded 1980, 50 members, Observatory with 14" scope. Operates a HAM radio net for amateur astronomy.

PENNSYLVANIA

Allentown: Lehigh Valley Amateur Astronomical Soc., East Rock Rd., 18103, Rod Hatcher, (908) 859-6441, Founded 1957, 200 members, Observatory (20" scope).

Beaver: Beaver Valley Astronomy Club, 1335 3rd St., #2, 15009, David Yoder, (412) 728-5255. Founded 1975, 20 members.

Clarks Summit: Lackawanna Astronomical Society, 1112 Fairview Road, 18411, John D. Sabia, (717) 586-0789. Founded 1959, 94 members, public observing at Keystone Junior College Observatory (9" Clark refractor).

Erie: M-31 Astronomical Society, 86 Applewood Lane, 16509.

Glenshaw: Amateur Astronomers Assoc. of Pittsburgh, P.O. Box 314, 15116, John Holtz, (412) 224-2510. Founded 1929, 230 members, Observatory with 12.5" Newtonian. Monthly public star parties at Wagman Observatory.

Haverford: Rittenhouse Astronomical Society, 216 Elbow *Lane, 19041,* Nancy Blossom, (215) 642-4337. *80 members.*

Kane: Sir Isaac Newton Astronomical Society, 434 Greeves St., 16735, William Kearney. 15 members.

Kimberton: Delaware Valley Amateur Astronomers, P.O. Box 662, 19442-0662, Marilyn Michalski, (215) 933-0497. Founded 1976, 160 members. Monthly public star parties.

Lansdale: L5 Society of Philadelphia, 1825 Flintlock Circle, 19446, Jay B. Haines, (215) 855-7130.

Lewisberry: Astronomical Society of Harrisburg, P.O. Box 356, 17339, (717) 938-6041. Founded 1955, 170 members. Observatory with 17.5" telescope. Public observing every clear Sun. evening, June-Aug.

New Kensington: Kiski Astronomers, 69 Aluminum City Terrace, 15068, Dennis Sopchack, (412) 337-0509. Founded 1968, 30 members.

Penns Park: Bucks-Mont Astronomical Association, P.O. Box 37, 18943, Dick Sivel. 49 members.

Reading: Berks County Amateur Astronomical Society, Reading School District Planetarium, 1211 Parkside Dr. South, 19611, Linda Sensenig, (215) 375-9062. Founded 1973, 40 members.

York: York County Parks Astronomical Society, 400 Mundis Race Road, 17402, Jeri Jones, (717) 225-3744. Founded 1989, 35 members.

PUERTO RICO

Rio Piedras: Sociedad de Astron. de Puerto Rico Inc., Montevideo 797, Las Americas, 00921, Benito Aponte, (809) 765-0889. Founded 1985, 70 members. Meetings conducted in Spanish.

RHODE ISLAND

Newport: Celestial Observers of Rhode Island, 10 Redcross Terrace, 02840, John Hopf, (401) 521-5680. 45 members.

North Scituate: Skyscrapers Inc., 47 Peep Toad Road, 02857,Conrad Cardano, (401) 828-0702, 100 members. Observatory with 8" Clark refractor & 20" reflector. Public viewing nights.

SOUTH CAROLINA

Aiken: Aiken Astronomy Club, USC-Aiken, Buliding 106, 171 University Parkway, 29801, Richard M. Albert, (803) 663-3105.

Central: Clemson Area Astronomers, 1550 Old Seneca Road, 29630-9597, Dixon Lomax, (803) 656-2197. Founded 1982, 75 members.

Greenville: Roper Mountain Astronomers, 504 Roper Mountain Road, 29615, Doug Gegen, (803) 288-8595. Assists in operation of Daniel Observatory (23" Clark refractor).

Hanahan: Lowcountry Stargazers, 1313 Springhill Road, 29406, John Smith, (803) 797-0146. Founded 1983, 50 members, Observatory with 16" scope.

Rock Hill: Carolina Stargazers Astronomy Club, Museum of York County, 4621 Mt. Gallant Road, 29730, M. Leon Knott, (803) 329-2121. Founded 1986, 95 members. Operates "Have Telescope, Will Travel" program.

West Columbia: Midlands Astronomy Club, P.O. Box 4321, 29171, Luke Rohlfing, (803) 772-5634. Founded 1970, 85 members.

SOUTH DAKOTA

Rapid City: Black Hills Astronomical Society, 4912 Breckenridge Court, 57702, Michael O'Connor, (605) 342-3793. Founded 1954, 30 members, Observatory with 12.5" Newtonian. Public viewing nights.

TENNESSEE

Brentwood: Barnard-Seyfert Astronomical Soc., A . J. Dyer Observatory, 1000 Oman Dr., 32027, A. Heiser, (615) 373-4897. Founded 1923, 72 members.

Chattanooga: Barnard Astronomical Society, P.O. Box 90042, 37412, F. Randolph Helms, (615) 622-4762. Founded 1923, 38 members, Observatory with 20.5" scope. Public viewing nights.

Kingsport: Bays Mountain Amateur Astronomers, 853 Bays Mountain Park Road, 37663, (615) 229-9447. Founded 1980, 50 members, Observatory with 17.5" reflector & 8" refractor.

Kingsport: Bristol Astronomy Club, 824 Hidden Valley Road, 37663, Ken Childress, (615) 239-3638. Founded 1955, 24 members, Observatory with 12.5" reflector. Public viewing nights.

Knoxville: Orion Research Forum and Network, P.O. Box 50291, 37950, Bob Miles. Founded 1974, 12 members.

Knoxville: Smoky Mountain Astronomical Society, P.O. Box 6204, 516 Beaman St., 37914-0204, Rita Fairman, (615) 637-1121. 30 members.

Manchester: Middle Tennessee Astronomy Society, 1305 Sycamore St., 37355, Donald W. Male, (615) 728-7321. Founded 1957, 15 members.

Memphis: Memphis Astronomical So., 1229 Pallwood Rd., 38122, Richard Moore, (901) 682-2003. Founded 1957, 55 members, Observatory with 16" scope.

Memphis: Society of Low Energy Observers, 4277 Park Forest Dr., 38141, Kathey Nix. 11 low-energy members.

TEXAS

Abilene: Abilene Astronomical Society Inc., 1109 Highland Ave., 79605, George Schroeder, (915) 677-5713.

Amarillo: Amarillo Astronomy Club, 4324 Summit Circle, 79109, Danny Zumbrun.

Austin: Austin Astronomical Society, P.O. Box 12831, 78711, Larry Kemp. Founded 1970, 90 members, Observatory with 12.5" reflector. Public viewing nights.

Baycliff: JSC Astronomical Society, 4802 Redfish Reef, 77518.

Beaumont: Astronomical Society of South East Texas, P.O. Box 7943, 77726-7943, Jim Heintzleman, (409) 892-2207. Founded 1990, 22 members.

College Station: Association of Amateur Astronomers, Texas A&M University, Dept. of Physics, 77843-4242, Roger Smith, (409) 845-4179.

Corpus Christi: Corpus Christi Astronomical Society, 3814 Marion St., 78415, Gary Mayer, (512) 852-7643. Founded 1965, 10 members.

Dallas: Texas Astronomical Society, P.O. Box 25162, 75225, Sharon Cherry, (214) 358-6982. Founded 1946, 325 members.

Ft. Worth: Ft. Worth Astronomical Society, P.O. Box 161715, 76161-1715, Wade Weaver, (817) 731-0804. Founded 1949, 120 members, Observatory with 12" scope.

Ft. Worth: General Dynamics Astronomy Club, 3400 Bryant-Irvin Road, 76109, Ronald W. Evans, (817) 763-6244.

Ft. Worth: Texas Observers, 1501 Montgomery St., 76107, Don Garland, (817) 732-1631. Founded 1986, 15 members.

Houston: Houston Astronomical Society, P.O. Box 20332, 77225-0332, John Chauvin, (713) 639-3452. Founded 1955, 410 members, Observatory with 14" scope.

Houston: Students for the Exploration & Development of Space, University of Houston, 2700 Bay Area Blvd. Box 198, 77058, Carlos Perez, (713) 486-9359. Founded 1987, 60 members.

Lake Jackson: Brazosport Astronomical Soc., 500 College Dr., 77566, Steve Lamb, (409) 297-3984.

Lubbock: South Plains Astronomy Club, 1920 46th St., 79412-2214, Wayne Lewis, (806) 763-6800. Founded 1960, 30 members.

McAllen: Valley Astronomical Society, 7005 North 31st St., 78504.

Odessa: Permian Basin Astronomical Society, Box 301, 79760, F.A. McElvaney. Founded 1986, 6 members.

San Angelo: San Angelo Amateur Astronomy Assoc., P.O. Box 60391, 76906, Joseph Lynch, (915) 944-2113. Founded 1964, 32 members.

San Antonio: San Antonio Astronomical Association, 6427 Thoreau's Way, 78239, Rick Garcia, (512) 654-9784. 73 members.

Sanger: Denton County Astronomical Society, 225 Green Springs Circle, 76266, John Love, (817) 458-7479.

Stafford: Fort Bend Astronomy Club, P.O. Box 942, 77477-0942, Dennis Zwicky, (713) 499-4993. Founded 1984, 70 members. Assists with operation of 36" scope at George Observatory.

Texas City: College of the Mainland Astronomy Club, Division of Natural Science, 77591, John L. Hubisz, (409) 938-4098. Founded 1973, 10 members.

Tyler: Astronomical Society of East Texas, Hudnall Planetarium, P.O. Box 9020, 75711, Mike Mikule, (214) 561-3710. Founded 1987, 30 members.

Victoria: Crossroads Astronomy Club, 233 Spur Dr., 77094, Derek Newton, (512) 578-5452. Founded 1990, 7 members.

Waco: Ursa Major Astronomy Society, Baylor University, Box 7316, 76798.

UTAH

Cedar City: Southern Utah Astronomy Group, 147 South 300 East, 84720, Brent Sorensen, (801) 586-2759. Founded 1986, 8 members, Observatory with 14" SCT. Public viewing nights.

Roy: Ogden Astronomical Society, 2336 West 5650 South, 84067, Bob Tillotson, (801) 773-8106.

Salt Lake City: Salt Lake City Astronomical Soc., 15 South State St., 84111, (801) 538-2104. Founded 1967, 150 members, Observatory with 16" and trailer-mounted 20". Public viewing nights.

VERMONT

Williston: Vermont Astronomical Society, P.O. Box 782, 05495, Frank Pakulski, (802) 985-3269. Founded 1964, 55 members, Observatory with 10" scope.

VIRGINIA

Bassett: Piedmont Astronomy Club, P.O. Box 865, 24055, James I. Marshall.

Blacksburg: Astronomy Club of Virginia Tech, Virgina Polytechnic Inst., Physics Dept., 24061, John Abbott, (703) 951-3518. Founded 1970, 45 members, Observatory (14" SCT). Public viewing nights. Call 231-5719 for times.

Chesapeake: Back Bay Amateur Astronomers, 2808 Flag Road, 23323, Glendon L. Howell, (804) 485-4242. Founded 1978, 13 members. Monthly public star parties at Northwest River Park.

Fredericksburg: Triangulum Astronomical Society, P.O. Box 7464, 22404, Al Ventura Jr., (703) 775-2337. Founded 1983, 9 members.

Hampton: Skywatchers, 109 Mill Point Dr., 23669-3534, Marilyn Ogburn, (804) 723-7453. Founded 1945, 20 members, Observatory with 16" scope. Public viewing nights.

Harrisonburg: Shenandoah Valley Astronomy Club, James Madison University, Dept. of Physics, 22801, Henry W. Leap, (703) 568-6109.

Lynchburg: Lynchburg Astronomy Club, 4648 Locksview Road, 24503, Allen Majewski, (804) 384-5616.

Nathalie: Halifax Skywatchers, P.O. Box 22, 24577-0022, Joe Lightcap, (804) 349-3700. Founded 1986, 20 members.

Portsmouth: Astronomical Society of Tidewater, 4205 Faigle Road, 23703, Leonard Scarr, (804) 464-3880. Founded 1975, 20 members, Observatory (10" reflector). Public viewing nights.

Portsmouth: Tidewater Community College Astronomical Society, Physics Dept., State Route 135, 23703, Aubrey Hartman, (804) 488-4354. Founded 1982, 50 members, Observatory with 14" SCT. Bi-monthly public nights.

Reston: Nova Space Society, 11208 Chestnut Grove Square #5, 22090-5105, Gary Sanger, (703) 435-0019.

Richmond: Richmond Astronomical Soc., 4204 Northwich Rd., Midlothian, 23112, Tom Bernhardt, (804) 744-1220. Founded 1949, 55 members, Observatory (7" refractor.

Roanoke: Roanoke Valley Astronomical Society, 3721 Colony Lane SW, 24018, Gary Close, (703) 989-3474.

Springfield: Northern Virginia Astronomy Club, 6121 Rivanna, 22150, Al Schumann, (703) 256-8359. Founded 1980, 107 members.

Virginia Beach: Tidewater Amateur Telescope Makers, 677 Charlecote Dr., 23464, Don Wright, (804) 424-9430. Founded 1977, 20 members.

WASHINGTON

Bellinghman: WACO - Whatcom Assoc. of Celestial Observers, 3700 Taylor Ave., 98226, Tom Masterson, (206) 734-5821. Founded 1988.

Centralia: Southwest Washington Astronomical Society, 2421 Leisure Lane, 98531, Carl M. Newton, (206) 736-6144. Founded 1975, 50 members. Hosts star parties at Goldendale Observatory.

Keyport: Olympic Astronomical Society, P.O. Box 458, 98345, Roger Miller, (206) 698-0381. Founded 1969, 85 members.

Richland: Tri-City Astronomy Club, P.O. Box 651, 99352, Jerry Johnson, (509) 783-8806. Founded 1984, 45 members.

Seattle: Seattle Astronomical Society, 14454 119th Place NE, Kirkland, 98034, Marjie Kichline, (206) 523-ASTR. 180 members.

Seattle: Boeing Employees Astronomical Society, The Boeing Company, P.O. Box 3707, Mail Stop 4H-58, 98124, Walter Hazen, (206) 657-6488. Founded 1980, 100 members, 20" portable telescope.

Spokane: Spokane Astronomical Soc., P.O. Box 8114, 99203-8114, Thom Jenkins, (509) 838-1381. Founded 1936, 85 members.

Tacoma: Tacoma Astronomical Society, 7101 Topaz Dr. SW, 98498, (206) 588-9504. 80 members.

WEST VIRGINIA

Cross Lanes: Kanawha Valley Astronomical Society, 5204 Dellway Dr., 25313, Roger Chapman. 35 members.

Tridelphia: Oglebay Institute Astronomical Association, Box 436 Chapel Hill, 26059, Henry Winchester. 6 members.

WISCONSIN

Beloit: Rock Valley Astronomical Society, 2220 E. Ridge Road, 53511.

Fall Creek: Chippewa Valley Astronomy Society, Hobbs Observatory, Route 2, Box 94, 54742, Bob Elliott, (715) 877-2787. Founded 1982, 25 members, Observatory with 24" reflector.

Franklin: Wehr Astronomical Society, 9701 West College Ave., 53132, Karen Kerans, (414) 425-8550. Founded 1981, 90 members. Monthly public star parties at Bong State Recreational Area.

Grafton: Northern Cross Science Foundation, 1327 - 11th Ave., 53024, William Fisher, (414) 377-0468. Founded 1974, 45 members, Observatory with 17.5" scope. Monthly public viewing nights.

Green Bay: Neville Museum Astronomical Society, 210 Museum Place, 54303, Donn Quigley, (414) 436-3767. Founded 1966, 50 members, Observatory with 30" Cassegrain.

La Crosse: La Crosse Area Astronomical Society, P.O. Box 2041, 54602-2041, Robert Allen, (608) 785-8669.

Madison: Madison Astronomical Society Inc., 404 Prospect, Waunakee, 53597, Bob Manske, (608) 849-5287. Founded 1930, 75 members, Observatory with 17.5", 16", & 11" scopes.

Milwaukee: Milwaukee Astronomical Soc., W248 S7040 Sugar Maple Dr., Waukesha, 53186, Daniel Koehler, (414) 662-2987. Founded 1932, 350 members, Observatory (25" Cassegrain). Biweekly public viewing nights July-Oct. Call 542-9071 for dates.

Oshkosh: NEWSTAR-Northeast Wisconsin Stargazers, 1815 Kienast Ave., 54901, Don Wyman, (414) 233-3083. Founded 1986, 45 members.

Racine: Racine Astronomical Soc., P.O. Box 085694, 53408, Don Sorenson, (414) 878-2774. Founded 1956, 70 members, Modine-Benstead Observatory (16" scope). Weekly public nights.

Sheboygan: Sheboygan Astronomical Society, 1712 N. 6th St., 53081.

WYOMING

Cheyenne: Cheyenne Astronomical Soc., 3409 Frontier St., 82001, Marcy Flint, (307) 632-2717. Founded 1986, 42 members.

CANADA

ALBERTA

Calgary: RASC - Calgary Centre, Alberta Science Centre, P.O. Box 2100, Station M, T2P 2M5, Founded 1958, 200 members, Observatory with 14" scope. Public viewing nights.

Edmonton: RASC - Edmonton Centre, 4203 - 106 B Ave., T6A LK7, Mel Rankin. Founded 1932, 120 members, portable 17.5" Dobson.

Fort McMurray: Astronomical Society of Fort McMurray, 113 Auger Court, T9J 1E5. Founded 1986, 10 members.

Lethbridge: Lethbridge Astronomy Society, P.O. Box 1104, T1J 4A2, Rick Ponomar, (403) 381-1332. Founded 1988, 30 members.

BRITISH COLUMBIA

Prince George: Prince George Astronomical Soc., College of New Caledonia, 3330-22nd Ave., V2N 1P8, Bob Nelson, (604) 562-2131. Founded 1979, 15 members, Observatory (61cm telescope).

Vancouver: RASC - Vancouver Centre, Gordon Southam Observatory, 1100 Chestnut St., V6J 3J9.

Vernon: Okanagan Astronomical Society, 4100 25th Ave., V1T 1P4, Peter Kuzel, (604) 545-1226.

Victoria: RASC - Victoria Centre, 801 Stanehill Place, RR #1, V8X 3W9, A. Newton, (604) 478-8065.

MANITOBA

Brandon: Westman Astronomy Club, 32 Ashgrove Blvd., R7B 1C2, Jeff Harland, (204) 726-8294. Founded 1985, 35 members.

Winnipeg: Manitoba Astronomy Club, 190 Rupert Ave., R3B 0N2, Doug Knight, (204) 956-2830. Junior astronomers club. Meets at Manitoba Planetarium.

Winnipeg: RASC - Winnipeg Centre, P.O. Box 215, St. James Post Office, R3J 3R4. Operates Glenlea Observatory.

NEWFOUNDLAND

Mount Pearl: RASC - St. John's Centre, P.O. Box 944, A1N 3C9, Peter Allston.

NOVA SCOTIA

Halifax: RASC - Halifax Centre, 1747 Summer St., B3H 3A6, Douglas Pitcairn, (902) 463-7196. Founded 1955, 160 members.

ONTARIO

Belle River: RASC - Windsor Centre, 453 East Belle River Road, Rural Route 2, N0R 1A0, Lorison Durocher, (519) 728-1332. Founded 1943, 71 members, Observatory with 8" scope.

Kingston: RASC - Kingston Centre, P.O. Box 1793, K7L 5J6, Kim Hay, (613) 353-1189. Founded 1961, 48 members.

London: Astronomy London, RASC - London Centre, P.O. Box 842, Station B, N6A 4Z3, Eric Clinton. Founded 1922, 45 members.

Niagara Falls: RASC - Niagara Centre, P.O. Box 241, L2E 6T3, Gregory Saxon, (416) 732-5560. Founded 1958, 60 members, Observatory with 17.5" scope.

Ottawa: RASC - Ottawa Centre, P.O Box 6617, Station J, K2A 3Y7. Founded 1906, 250 members, Observatory with 16" Newtonianß.

Scarborough: Metropolitan Toronto Astronomical Society, 154 John Tabor Trail, M1B 2P8, Steve Spinney.

Sudbury: Sudbury Astronomy Club, 859 Chestnut Crescent, P3A 5B3, Fred Boyer, (705) 560-3265.

Thunder Bay: RASC - Thunder Bay Centre, 545 Parkway Dr., P7A 5C9, Mrs. B. Connell. Founded 1988, 30 members.

Toronto: North York Astronomical Association, 26 Chryessa Ave., M6N 4T5, Andreas Gada, (416) 761-1798. Founded 1980, 50 members, Observatory with 16" Dobsonian.

Toronto: RASC - Toronto Centre, McLaughlin Planetarium, 100 Queen's Park, M5S 2C6, B. Ralph Chou, (416) 777-4300. Founded 1868, 1,030 members.

Waterdown: RASC - Hamilton Centre, P.O. Box 1223, L0R 2H0, Pauline Wright, (416) 689-5717. Founded 1908, 80 members, Observatory with 17.5" scope. Public viewing nights.

Waterloo: RASC - Kitchner-Waterloo Centre, 114 Westvale Dr., N2T 1J2, Paul Bigelow, (519) 888-7516. Founded 1980, 30 members, Observatory with 12.5" scope.

Wyoming: RASC - Sarnia Centre, Box 103, N0N 1T0. Founded 1980, 10 members.

PRINCE EDWARD ISLAND

Summerside: Athena Community Astronomy Club, P.O. Box 2500, C1N 4L9, 50 members.

QUEBEC

Montreal: RASC - Le Societé de Astronomie-Montreal, Casier Postal 206, Ste. Michael, H2A 3L9, Mark Gelinas.

Montreal: RASC - Montreal Centre, P.O. Box 1752, Station B, H3B 3L3, Louie Bernstein, (514) 845-2612. Founded 1918, 140 members, Observatory with 14" SCT.

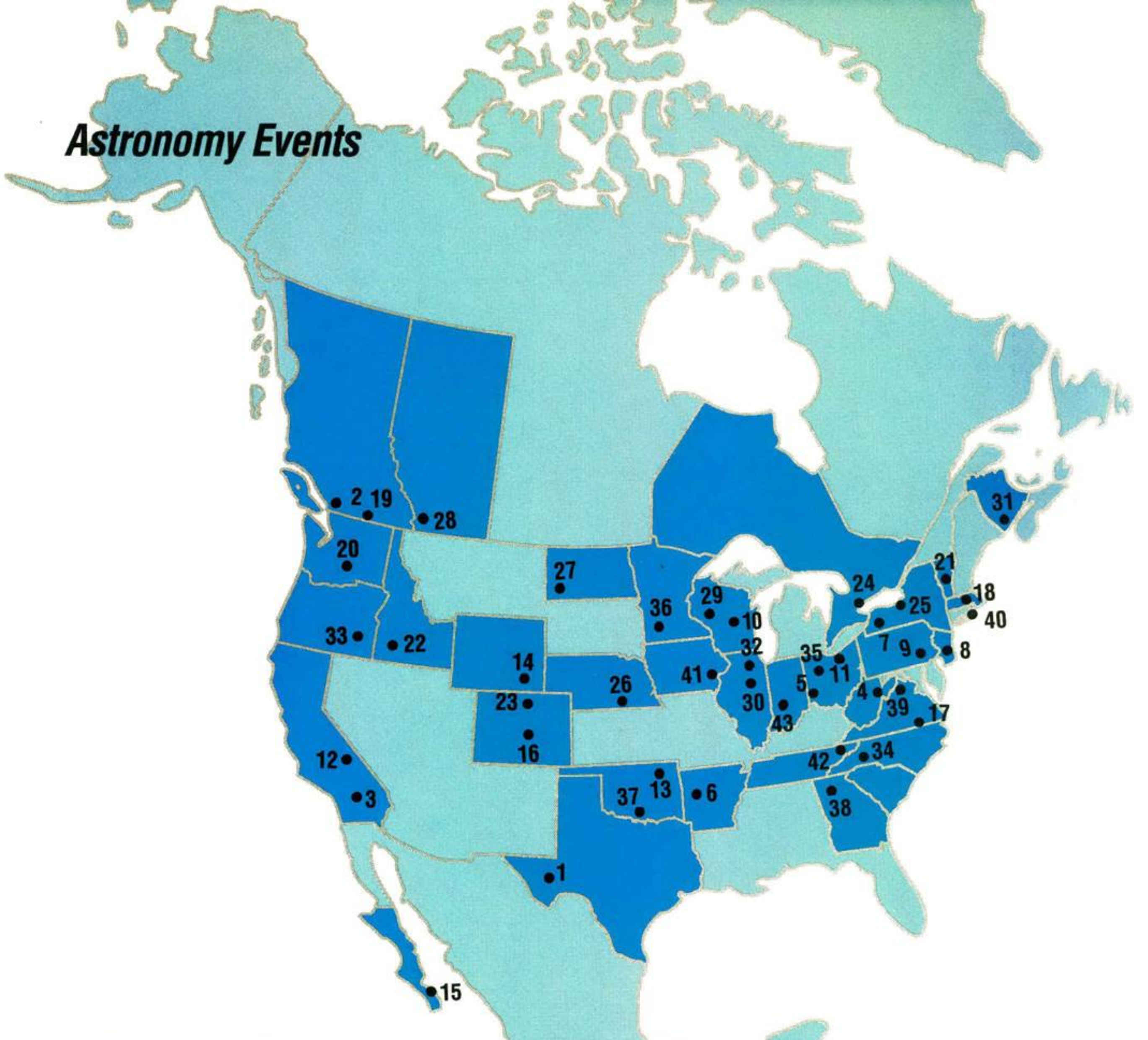
Ste. Foy: RASC - Quebec Centre, Casier Postal 9396, G1V 4B5, (418) 626-9592. Founded 1942, 75 members.

SASKATCHEWAN

Regina: RASC - Regina Centre, P.O. Box 6735, S4S 7E6. Founded 1989, 30 members.

Saskatoon: RASC - Saskatoon Centre, Box 317, Sub. P.O. Box #6, S7N 0W0, Mike Wesolowski, (306) 373-0137. Founded 1968, 45 members, Observatory with 8" scope.

Astronomy Events



The calendar is filled with astronomical activities over the next few months. Star parties and conventions are a great way to meet fellow amateur astronomers, see many varieties of telescopes, and explore the sky more thoroughly than you might ever do on your own. If there is a regional star party in your area, be sure to attend. In addition to the events listed here, many astronomy clubs hold local star parties that are open to the public in their communities. These are sometimes held around the time of the Perseid meteor shower in mid-August. Contact the astronomy club or planetarium nearest you to learn what's happening in your town. Also, be sure to check our Meetings and Events department each month for more listings of astronomical events. — *Alan Dyer*

MAY

1 May 12 – 19
Texas Star Party, Prude Ranch, Fort Davis, Texas. One of the big three star parties, along with Riverside and Stellafane. Contact: Bobby Braley, Registrar, Dept. A., P.O. Box 386, Wylie, TX 75098.

2 May 17 – 19
General Assembly of the Royal Astronomical Society of Canada, Vancouver, B.C. Contact: Vancouver Centre – R.A.S.C., c/o Gordon Southam Observatory, 1100 Chestnut Street, Vancouver, B.C., Canada V6J 3J9, David Dodge.

3 May 24 – 27
Riverside *Telescope Makers Conference*, Camp Oakes, Big Bear Lake area, California. Contact: RTMC, Fox and Stephens, CPA, 9045 Haven Avenue #109, Rancho Cucamonga, CA 91730, (714) 948-2205.

JUNE

4 June 10 – 12
Society of Amateur Radio Astronomy Conference, National Radio Astronomy Observatory, Green Bank, West Virginia. Contact: S.A.R.A, 247 North Linden Street, Massapequa, NY 11758, (516) 798-8459.

5 June 14 – 15
Apollo Rendezvous and Telescope Fair, Dayton Museum of Natural History, Ohio. Contact: Miami Valley Astronomical Society, 5932 Culzean Drive #706, Trotwood, OH 45426, Ian Dumbauld, (513) 256-0673.

6 June 14 – 16
Arkansas Star Party, Coleman Memorial Observatory, 25 miles south of Ft. Smith, Arkansas. Contact: Arkansas-Oklahoma Astronomical Society, c/o Coleman Memorial Observatory, Route 1, Box 404, Hackett, AR 72937.

7 June 14 – 16
Astronomy Weekend '91, Martz Observatory, Frewsburg, New York. Contact: Tom Bemus, RD #3, Box 161A, Bemus Point, NY 14712, (716) 386-4566 (evenings) or (716) 483-0343 (days).

8 June 14 – 16
Jersey Star Quest, Rutgers 4-H Camp, Beemerville, NJ. Contact: Amateur Astronomers Association of Princeton, P.O. Box 2017, Princeton, NJ 08540, Greg Mauro, (609) 585-9465.

9 June 14 – 16
Mason-Dixon Star Party, Spring Valley County Park, York, Pennsylvania. Contact: York County Parks Astronomical Society, 45 First Street, Windsor, PA 17366, Greg Markowski, (717) 244-4551 (days) or (717) 244-8476 (evenings).

10 June 14 – 16
Wisconsin Observer's Weekend, Hartman Creek State Park, Waupaca, Wisconsin. Contact: NEWSTAR, the Northeast Wisconsin Stargazers, 1815 Kienast Avenue, Oshkosh, WI 54901, Don Wyman, (414) 233-3083 (evenings).

11 June 15
Ohio Association of Amateur Astronomers Conference, Hiram College, Cleveland, Ohio. Contact: Cuyahoga Astronomical Association, P.O. Box 29089, Cleveland, OH 44129-0089, Dawn Jenkins, (216) 521-5115, or Allan Jenks (216) 237-4223.

12 June 15 – 17
Star Gazing Expedition, Camping trip to White Mountains, California. Contact: Santa Monica Amateur Astronomy Club, 1415 Michigan Avenue, Santa Monica, CA 90404, Robert Lozano, (213) 450-1944.

13 June 16
Prairie Song Star Party, Prairie Song Western Village, Bartlesville, Oklahoma. Contact: Bartlesville Astronomical Society, 225 SE Fenway Place, Bartlesville, OK 74006, Ken Willcox, (918) 333-1966 (evenings) or (918) 336-9900 (days).

14 June 22 – 27
Astronomical Society of the Pacific Annual Meeting, at University of Wyoming, Laramie. Symposia, nontechnical talks, teachers' workshops, and a star party. Sponsored in part by ASTRONOMY Magazine. Contact: A.S.P., Wyoming Meeting Info., 390 Ashton Avenue, San Francisco, CA 94112, (415) 337-1100.

JULY

15 July 8 – 12
Research Amateur Astronomy Symposium, La Paz, Baja California Sur, Mexico. Contact: Corporation for Research Amateur Astronomy, P.O. Box 16542, San Francisco, CA 94116. Concurrent with R.A.S. Symposium:
Association of Lunar and Planetary Observers Convention, La Paz, Baja California Sur, Mexico. Contact: A.L.P.O., P.O. Box 143, Heber Springs, AR, 72543, (501) 362-7624.

16 July 12 – 13
Annual Star Stare Campout and Star Party, Badger Flats, Colorado. Contact: Colorado Springs Astronomical Society, P.O. Box 62022, Colorado Springs, CO 80962, Jim Lawrence, (719) 593-0801.

17 July 13
Tidewater Star Party, Portsmouth Campus, Tidewater Community College, Portsmouth, Virginia. Contact: Tidewater Community College Astronomical Society, Physics Dept., State Route 135, Portsmouth, VA 23703, Aubrey Hartman, (804) 488-4354 (evenings) or (804) 484-2121 ext. 235 (days).

AUGUST

18 August 7 – 9
ALCON 91, annual national convention of the Astronomical League, at University of Massachusetts at Amherst. Hosted by the Amateur Telescope Makers of Boston. Contact: John Reed, 1991 Convention Chairman, 1437 Massachusetts Avenue, Lexington, MA 02173, (617) 861-8031.

19 August 7 – 11
Mount Kobau Star Party, summit of Mount Kobau near Osoyoos, British Columbia. Contact: Peter Kuzel, 4100 25th Avenue, Vernon, B.C., Canada V1T 1P4, (604) 545-1226.

20 August 9 – 10
Northwest Astronomical League Convention and Star Party, Table Mountain, near Ellensburg, Washington. Contact: Thom Jenkins, 3312 South Pittsburgh, Spokane, WA 99203, (509) 838-1381.

21 August 9 – 10
Stellafane, the Northeast's biggest star party, near Springfield, Vermont. Begun in the 1930s, Stellafane now attracts 3,000 people a year. Contact: Stellafane, 60 Victoria Road, Sudbury, MA 01776.

22 August 9 – 10
Weekend Under the Stars, Bruneau Sand Dunes State Park, Mountain Home, Idaho. Contact: Boise Astronomical Society Inc., P.O. Box 8386, Boise, ID 83707, Art Martini, (208) 362-2074.

23 August 9 – 11
Mountain Astronomers Rendezvous and Star Party, Parachute, Colorado. Contact: Denver Astronomical Society, P.O. Box 10814, Denver, CO 80210, Dave Trott, (303) 871-5172.

24 August 9 – 11
Starfest '91, Riverplace Campground, Mount Forest, Ontario. Contact: North York Astronomical Association, 26 Chryessa Avenue, Toronto, Ontario, Canada M6N 4T5, Andreas Gada, (416) 761-1798 (evenings) or (416) 766-8233 ext. 5463 (days).

25 August 9 – 11
Syracuse Summer Seminar, Darling Hill Observatory, Vesper, New York. Contact: Syracuse Astronomical Society, 706 Campbell Road, Mattydale, NY 13211, Rob McCabe.

26 August 10
Prairie Astronomy Club Star Party, Hyde Observatory, Holmes Park, Lincoln, Nebraska. Contact: Prairie Astronomy Club, P.O. Box 80553, Lincoln NE 68501, Lee Thomas, (402) 483-5639.

27 August 10 – 11
Dakota Star Watch, Killdeer Mountains, North Dakota. Contact: Dakota Astronomical Society, P.O. Box 2539, Bismarck, ND 58502, John Wetsch, (701) 256-3620 (evenings).

28 August 10 – 11
Alberta Star Party, Waterton Lakes National Park. Contact: Lethbridge Astronomy Society, P.O. Box 1104, Lethbridge, Alberta, Canada T1J 4A2, Rick Ponomar, (403) 381-1332 (evening) or (403) 381-3744 (days).

29 August 16 – 18
Northwoods Starfest, Hobbs Observatory Center, Beaver Creek Reserve, WI. Sponsored by the Chippewa Falls Astronomical Society. Contact: Bob Elliott, Hobbs Observatory, Route 2, Box 94, Fall Creek, WI 54742, (715) 877-2787.

30 August 23 – 25
Astronomy Rendezvous and Conference, Normal, Illinois. Contact: Twin City Amateur Astronomers, P.O. Box 755, Normal, IL 61761, Sharon MacDonald, (309) 827-4885 (evenings).

31 August 30 – September 2
Nova East '91, Fundy National Park, New Brunswick. Contact: Halifax Centre of the R.A.S.C., 1747 Summer Street, Halifax, Nova Scotia, Canada B3H 3A6, Douglas Pitcairn, (902) 463-7196.

SEPTEMBER

32 September 6 – 8
Astrofest '91, Shaw-Waw-Nas-See 4H Camp, Kankakee, Illinois. The largest midwest star party. Hosted by the Chicago Astronomical Society. Contact: Astrofest, P.O. Box 596, Tinley Park, IL 60477, Alan Birkner, (708) 966-6214.

33 September 6 – 8
Oregon Star Party and Campout, Steens Mountain, 60 miles south of Burns, Oregon. Sponsored by Rose City Astronomers of Portland. Contact: Oregon Star Party, Oregon Museum of Science and Industry, 4015 SW Canyon Road, Portland, OR 97221, Chuck Dethloff, (503) 629-2145.

34 September 7
Blue Ridge Parkway Regional Stargaze, Julian Price Park, 4.5 miles south of Blowing Rock, NC. Part 2 of event held October 5. Contact: Greg Kirby, Route 3, Box 472, Granite Falls, NC 28630, (704) 396-7656.

35 September 7 (tentative)
Ohio Turnpike Astronomers Association Convention, Strawberry Mountain, Ohio. Contact: Black River Astronomical Society, 1631 Maple Drive, Lorain, OH 44082, Michael Harkey, (216) 288-8556.

36 September 13 – 15
Southern Minnesota Sky Show, farm site 7 miles from New Ulm, Minnesota. Alternative date: September 20 – 22. Send SASE to: Minnesota Valley Amateur Astronomers, Route 4, Box 15A, New Ulm, MN 56073, Roger Dier, (507) 359-2488.

OCTOBER

37 October 1 – 6
Okie-Tex Star Party, Lake Murray State Park, near Ardmore, Oklahoma. Contact: Oklahoma City Astronomy Club, P.O. Box 21221, Oklahoma City, OK 73156, Clive or Beryl Cadle, (405) 789-3742.

38 October 3 – 6
Georgia Star Party, Hard Labor Creek Observatory, Atlanta, Georgia. Contact: Astronomical Society of the Atlantic, Inc., c/o Center for High Angular Resolution Astronomy, Georgia State University, Atlanta, GA 30303, Don Barry, (404) 651-2932 (days).

39 October 4 – 5
Northern Virginia Telescope Meet, C.M. Crockett Park, Calverton, Virginia. Send long SASE to: Al Schumann, 6121 Rivanna Drive, Springfield, VA 22150, (703) 256-8359.

40 October 4 – 6
Astronomy Jamboree, Custer Institute, Southold, New York. Contact: Custer Institute Observatory, Box 1204, Main Bayview Road, Southold, NY 11971, Barbara Lebkuecher, (516) 722-3073 (evening) or (516) 722-3850 (days)

41 October 4 – 6
Eastern Iowa Star Party, location to be announced. Contact: Quad Cities Astronomical Society, P.O. Box 3706, Davenport, IA 52806, Wayne Jens, (319) 326-4995.

42 October 12
Starfest '91 Contact: Bays Mountain Amateur Astronomers, 853 Bays Mountain Park Road, Kingsport, Tennessee 37663, Charles Ferguson, (615) 229-9447 (days).

43 October 19
Star Watch 91, Butler University's Holcomb Observatory, Mooresville, Indiana. Contact: Indiana Astronomical Society, 2 Wilson Drive, Mooresville, IN 46158, J. Philip May, (317) 831-8387 (evenings) or (317) 831-3009 (days).

Astronomy Places

There's no shortage of astronomical places to visit on your travels this summer. During the rest of the year you may wish to explore the astronomical attractions in your own home town. For example, many colleges have small planetariums that are not open during the summer but present informative public programs during the school year. Whether you're looking for a place to visit, or a local source of astronomy information and advice, our listing of astronomical places should help get you in touch with your local astronomical community.

If your local facility is not included on our list, please contact us so we can update our database. — *Alan Dyer*

ALABAMA

Birmingham: Robert R. Meyer Planetarium, Birmingham Southern College, Box A-36, 35254, (205) 226-4770, 30' dome theater. Open 1st & 3rd Sat. and Sun.

Florence: Planetarium and Observatory, University of North Alabama, 35632, (205) 760-4284, 40' dome theater, observatory (14.5" telescope). Not open July & Aug.

Huntsville: Marshall Space Flight Center, 35812, (205) 544-0034.

Jacksonville: Jacksonville State University Planetarium, North Pelham Road, 36265, (205) 782-5616, 20' dome theater, observatory (12.5" telescope). Open by reservation.

ALASKA

Fairbanks: Geophysical Institute, University of Alaska–Fairbanks, Elvey Building, 99775, (907) 474-7598.

Juneau: Marie Drake Planetarium, 1250 Glacier Ave., 99801, (907) 586-3780.

ARIZONA

Amado: Multiple Mirror Telescope Observatory, P.O. Box 97, 85645, (602) 670-6741.

Flagstaff: Lowell Observatory, Mars Hill Road, 1400 West, 86001, (602) 774-3358, exhibits, tours, public observing (24" Clark refractor). Open daily in summer. Program info. line: 774-2096.

Flagstaff: Northern Arizona University Campus Observatory, Department of Physics & Astronomy, Box 6010, 86011, (602) 523-2661, 24" telescope. Open Thurs. evenings only.

Flagstaff: U.S. Naval Observatory, P.O. Box 1149, 86002, (602) 527-7000.

Tucson: Flandrau Planetarium, University of Arizona, Corner of Cherry & University Blvd., 85721, (602) 621-4515, 50' dome theater, Cinema 360, laser shows, exhibits, observatory. Open daily in summer. Program info. line: 621-STAR.

Tucson: Kitt Peak National Observatory, P.O. Box 26732, 85741, (602) 620-5350, Visitor Center at summit: exhibits, tours, lectures, films. Open daily till 4 p.m.

Tucson: Steward Observatory, University of Arizona, 85721, (602) 621-2288.

ARKANSAS

Little Rock: , University of Arkansas–Little Rock Planetarium, 2801 South University Ave., 72204, (501) 569-3259, 40' dome theater, laser shows, observatory (14.5" telescope). Open Fri. night & Sun. afternoon only. Program info. line: 569-3277.

CALIFORNIA

Apple Valley: Apple Valley Science and Technology Center, 22974 Bear Valley Road, 92308, (619) 247-7267.

Berkeley: Lawrence Hall of Science, University of California, 94720, (415) 642-5362, exhibits, 25' dome planetarium, public observing. Open daily in summer. Program info. line: 642-5133.

Big Bear City: Big Bear Solar Observatory, 40386 North Shore Lane, 92314, (714) 866-5791, open Sat. 4–6 p.m. July–Aug.

Cassel: Hat Creek Radio Observatory, University of California, Berkeley, Rt. 2, Box 500, 96016, (916) 335-2364, 85' dish + three 20' dishes. Open Mon.–Fri.

Chula Vista: Southwestern College Planetarium, 900 Otay Lakes Road, 91910, (714) 421-6700, 30' dome theater, observatory (12" telescope). Open by reservation only.

Edwards: NASA Hugh L. Dryden Flight Research Facility, P.O. Box 273, 93523, (805) 258-3460. Visitor Center. Open 7:45a.m.-3:45 p.m. weekdays. Tours at 10:15 and 1:15.

Eureka: College of the Redwoods Planetarium, Tompkins Hill Road, 95501, (707) 445-6831, 14' dome theater, observatory (14" telescope). Not open in summer.

Fresno: The Discovery Center, 1944 North Winery Ave., 93703, (209) 255-5533, public observing Fri. evenings in summer. Open Tues.–Fri.

Los Angeles: California Museum of Science & Industry, Exposition Park, 700 State Dr., 90037, (213) 744-7483, exhibits, IMAX® theater. Open daily.

Los Angeles: Griffith Observatory, 2800 East Observatory Road, 90027, (213) 664-1181, 75' dome theater, laser shows, exhibits, observatory (12" Zeiss refractor). Open daily in summer. Program info. line: 664-1191.

Los Angeles: University of California–Los Angeles, U.C.L.A. Department of Astronomy, 405 Hilgard Ave., 90024-1562, (213) 825-4434, planetarium, public observing. Not open in summer.

Moffett Field: NASA Ames Research Center, Office of Public Information, Mail Stop 204-12, 94035, (415) 604-6472. Open Mon. to Fri. daytime only.

Moffet Field: NASA Ames Research Center, Mail Stop TO-27, 94035, (415) 604-6497. Visitor Center, tours by reservation. Open Mon.-Fri. 9a.m.-4:30p.m.

Mount Hamilton: Lick Observatory, P.O. Box 55, 95140, (408) 274-5062, 120" & 40" reflectors, 36" refractor. Open daily, daytime only. Public observing through 40" & 36" on Fri. nights July 6–Aug. 31 by reservation only.

Oakland: Chabot Observatory and Planetarium, 4917 Mountain Blvd., 94619, (415) 531-4560, 30' dome theater, 20" refractor. Open Fri. & Sat. evenings.

Owens Valley: Owens Valley Radio Observatory, Robinson Laboratory, California Institute of Technology, Pasadena, 91125, (818) 356-4912.

Pasadena: Jet Propulsion Laboratory, 4800 Oak Grove, 91109, (818) 354-8593. Open 10 a.m.-3 p.m. weekdays by appointment only.

Pasadena: Mount Wilson Observatory, Mount Wilson Institute, 740 Holladay Road, 91106, (818) 793-3100, historic 100" & 60" reflectors.

Palomar Mountain: Palomar Observatory, California Institute of Technology, Pasadena 91125, (619) 742-2119, 200" Hale Telescope. Open daily in summer, daytime only.

Redding: Schreder Planetarium, 1644 Magnolia Ave., 96001, (916) 225-0250, 33' dome theater. Open Fri. evenings only. Not open in summer.

Rohnert Park: Sonoma State University Observatory, Department of Physics and Astronomy, 94928, (707) 664-2119, 14" telescope. Open one evening per month.

Sacramento: Sacramento Science Center, 3615 Auburn Blvd., 95821, (916) 449-8255, 30' dome planetarium. Open Wed.-Sun, afternoons only. Program info. line: 485-8836.

San Bernardino: San Bernardino Valley College Planetarium, 701 South Mt. Vernon Ave., 92410, (714) 888-6511, 30' dome theater, observatory (16" telescope). Open by reservation only. Not open in summer.

San Diego: Mount Laguna Observatory, Department of Astronomy, San Diego State University, 92182, (619) 594-6182, 21" telescope. Public observing Fri. & Sat. evenings June–Aug. by reservation only.

San Diego: Reuben H. Fleet Space Theater and Science Center, 1875 El Prado, Balboa Park, 92101, (619) 238-1233, 76' dome theater, laser shows, OMNIMAX® films. Open daily.

San Francisco: Exploratorium, 3601 Lyon St., 94123, (415) 563-7337. Open Wed.–Sun., daytime only + Wed. evenings.

San Francisco: Morrison Planetarium, California Academy of Sciences, Golden Gate Park, 94118, (415) 750-7127, 65' dome theater, laser shows, exhibits. Open daily in summer. Program info. line: 750-7141.

San Francisco: Planetarium and Observatory, San Francisco State University, 1600 Holloway Ave., 94132, (415) 338-1852, 27' dome theater, observatory (16" & 10" scopes). Open by reservation.

San Jose: Rosicrucian Planetarium and Science Center, Park & Nagalee Ave., 95191-0001, (408) 287-9171, 50' dome theater, exhibits. Open Tues.–Sun. daytime.

Santa Barbara: Gladwin Planetarium, Santa Barbara Museum of Natural History, 2559 Puesta del Sol Road, 93105, (805) 682-4711. 24' dome theater, public observing. Open daily. (Planetarium open Sat. & Sun.)

Santa Monica: Santa Monica College Planetarium, 1900 Pico Blvd., 90405, (213) 452-9223, 28' dome theater, observatory (10" telescope). Open Fri. evenings.

Santa Rosa: Santa Rosa Junior College Planetarium, 1501 Mendocino Ave., 95401, (707) 527-4640, 40' dome theater, public observing. Not open in summer.

Saratoga: West Valley College Planetarium, 14000 Fruitvale Ave., 95070, (408) 867-2200, 30' dome. Open by reservation.

Stockton: Clever Planetarium and Earth Science Center, San Joaquin Delta College, 5151 Pacific Ave., 95207, (209) 474-5051, 33' dome theater, Cinema 360, exhibits, public observing. Open Fri., Sat. & Sun. only. Program info. line: 474-5010.

Walnut: Mt. San Antonio College Planetarium, 1100 North Grand Ave., 91789, (714) 594-5611, 35' dome theater, public observing. Closed this summer.

COLORADO

Alamosa: Harry Zacheis Planetarium, Adams State College, 81102, (303) 589-7473. Open by reservation only.

Boulder: Fiske Planetarium and Science Center, University of Colorado, 80309-0408, (303) 492-5001.

Boulder: National Center for Atmospheric Research (NCAR), 1850 Table Mesa Dr., 80303, (303) 497-1174, exhibits, tours, and printed materials offered. Open daily, daytime only. Guided tours Mon.–Sat. at noon. from June 4 till Labor Day.

Colorado Springs: Black Forest Observatory, 12815 Porcupine Lane, 80908, (719) 495-3828, 32" telescope, exhibits. Reservations suggested.

Colorado Springs: U.S. Air Force Academy Planetarium, 5O ATS/DOP, 80840, (719) 472-2779, 50' dome theater. Open daily except Mondays in summer. Program info. line: 472-2778.

Denver: Chamberlin Observatory, University of Denver, Department of Physics, 80208, (303) 871-2238, 20" refractor. Open Tues. & Thurs. evenings only by reservation.

Denver: Gates Planetarium, Denver Museum of Natural History, 2001 Colorado Blvd., 80205, (303) 370-6351, 50' dome theater, laser shows, exhibits, IMAX®, observatory (22" telescope). Open daily in summer.

CONNECTICUT

Avon: Talcott Mountain Science Center, Montevideo Road, 06001, (203) 677-8571, observatory with 12" reflector. Open daily in summer.

Danbury: Planetarium, Western Connecticut State College, 06810, (203) 797-4218.

Middletown: Van Vleck Observatory, Wesleyan University, 06457, (203) 347-9411. Not open in summer.

Mystic: Mystic Seaport Museum & Planetarium, P.O. Box 6000, Greenmanville Ave., 06355, (203) 572-0711, 30' dome theater, public observing. Open daily in summer.

New Britain: Copernican Observatory and Planetarium, Central Connecticutt State University, Wells St., 06050, (203) 827-7852. Open Fri. & Sat. evenings.

New Haven: Southern Conn. State University Planetarium, Fitch and Pine Rock Streets, 06515, (203) 397-4351, 24' dome theater, observatory (12" telescope). Open by reservation only.

Stamford: Stamford Museum & Nature Center, 39 Scofieldtown Road, 06903, (203) 322-1646, 22' dome planetarium, exhibits, observatory (22" telescope). Open daily in summer.

West Hartford: Grengas Planetarium, Science Museum of Connecticut, 950 Trout Brook Dr., 06119, (203) 236-2961.

DISTRICT OF COLUMBIA

Washington: National Air and Space Museum, 6th St. & Independence Ave., SW, 20560, (202) 357-1529, extensive exhibits, Albert Einstein Planetarium (70' dome), IMAX® theater. Open daily.

Washington: Rock Creek Nature Center, 5200 Glover Road, N.W., 20015, (202) 426-6829, planetarium shows. Open daily.

Washington: U.S. Naval Observatory, 34th & Massachusetts Ave. NW, 20392, (202) 653-1543, 26" & 12" Clark refractors. Open Mon. evenings except holidays.

FLORIDA

Bradenton: Bishop Planetarium, 201 10th St. West, 34205, (813) 746-4132, 50' dome theater, laser shows, exhibits, observatory (6" refractor). Open Tues.–Sun. Program info. line: 746-STAR.

Cocoa: Astronaut Memorial Space Science Center, Brevard Community College, 1519 Clearlake Road, 32922, (407) 632-1111, 40' dome theater, Cinema 360, laser shows, exhibits, observatory (24" telescope). Open Mon.–Sat.

Davie: Buehler Planetarium, Broward Community College, 3501 SW Davie Rd., 33314, (305) 475-6681, 40' dome theater, laser shows, observatory (10" telescope). Open Fri., Sat., & Sun. only.

Daytona Beach: Museum of Arts and Sciences Planetarium, 1040 Museum Blvd., 32014, (904) 255-0285, Open Tues.–Sat.

Ft. Myers: Nature Center and Planetarium, 3456 Ortiz at Colonial, P.O. Box 06023, 33906, (813) 275-3435, 44' dome theater, laser shows, Cinema 360, public observing. Open Thurs.–Sun.

Gainesville: Observatory, University of Florida, 32601, (904) 392-2058, 12.5" telescope. Open Fri. evenings only.

Jacksonville: Alexander Brest Planetarium, Jacksonville Museum of Sciences and History, 1025 Gulf Life Rd., 32207, (904) 396-7062, 60' dome theater, public observing. Open daily in summer.

Kennedy Space Center: Kennedy Space Center Spaceport USA, Mail Code TWRS, 32899, (407) 452-2121. Exhibits, bus tours, IMAX® theater. Open daily.

Melbourne: Space Coast Science Center, 1510 Highland Ave., P.O. Box 36-1816, 32936, (407) 259-5572. Open Tues.–Sat.

Miami: Miami Space Transit Planetarium, 3280 South Miami Ave., 33129, (305) 854-4242, 65' dome theater, laser shows, exhibits, observatory (17.5" telescope). Open daily. Cosmic Hotline: 854-2222.

Orlando: John Young Planetarium, Orlando Science Center, 810 East Rollins St., 32803, (407) 896-7151, 40' dome theater, observatory (14" telescope), laser shows, exhibits. Open daily.

Pensacola: Owens Planetarium, Pensacola Junior College, 1000 College Blvd., 32504, (904) 484-2054, 30' dome theater. Open Thurs. evenings, Sept.–April.

St. Augustine: Fountain of Youth Planetarium, 155 Magnolia Ave., 32084, (904) 829-6138, 30' dome theater. Open daily.

St. Petersburg: Science Center of Pinellas Co. Planetarium, 7701 22nd Ave. North, 33710, (813) 384-0027, 16' dome theater. Open by reservation only.

St. Petersburg: St. Petersburg Junior College Planetarium, P.O. Box 13489, 5th Ave. North at 69th St., 33710, (813) 341-4320, 24' dome theater, observatory. Open Fri. evenings only.

Tallahasee: Florida State University Planetarium, Department of Physics, 32306, (904) 644-2098. Open by reservation only.

West Palm Beach: Aldrin Planetarium and Gibson Observatory, South Florida Science Museum, 4801 Dreher Trail North, 33405, (407) 832-1988. 30' dome theater, observatory (15.5" Newtonian). Open daily in summer.

GEORGIA

Albany: Wetherbee Planetarium, 100 Roosevelt Road, 31701, (912) 435-1572, 20' dome theater. Open by reservation.

Atlanta: Fernbank Science Center, 156 Heaton Park Dr. NE, 30307, (404) 378-4311, Jim Cherry Memorial Planetarium (70' dome), exhibits, observatory (36" telescope). Open daily in summer.

Columbus: Patterson Planetarium, 2900 Woodruff Farm Road, 31907, (404) 568-1730, 40' dome theater. Open by reservation only. Public observing weekly at Pine Mountain.

Dahlonega: North Georgia College, Physics Department, 30597, (404) 864-1511, Public observing with 16" telescope. Open by reservation only.

Decatur: Agnes Scott College Planetarium/Bradley Observatory, Agnes Scott College, 30030, (404) 371-6265, 12' dome theater, observatory (14" telescope). Open by reservation only. Not open in summer.

Macon: Museum of Arts and Sciences, 4182 Forsyth Road, 31210, (912) 477-3232, 40' dome planetarium, exhibits, observatory (14" telescope). Open daily in summer.

Rock Spring: Walker County Science Center, P.O. Box 10, Highway 95, 30739, (404) 764-1111, 24' dome theater, observatory (11" telescope). Open Mon.–Fri. by reservation only.

Savannah: Savannah Science Museum, 4405 Paulsen St., 31405, (912) 355-6705, exhibits, 24' dome planetarium, public observing. Open daily in summer.

Statesboro: Georgia Southern University Planetarium, Box 8031, 30460, (912) 681-5292, 40' dome. Not open in summer.

Valdosta: Valdosta State College Planetarium, Department of Physics, Astronomy and Geology, 31698, (912) 333-5752, 24' dome theater, exhibits, observatory (16" telescope). Open by reservation only.

Young Harris: Rollins Planetarium, Young Harris College, 30582, (404) 379-3990. Open Fridays.

HAWAII

Honolulu: Bishop Museum and Planetarium, 1525 Bernice St., P.O. Box 19000-A, 96817, (808) 848-4102, 30' dome theater, observatory (12" telescope). Open daily. Program info. line: 848-4136.

Honolulu: Mauna Kea Observatories, Institute for Astronomy, 2680 Woodlawn Dr., 96822, (808) 948-8312. Four-wheel drive vehicle recommended for drive to the summit of Mauna Kea on the Big Island. Visitor center at 9,000-foot level. Closed July 11.

Kamuela: Canada-France-Hawaii Telescope, Mauna Kea, P.O. Box 1597, 96743, (808) 885-7944, 3.6-meter telescope. Viewing gallery. Closed July 11.

IDAHO

Caldwell: Whettenberger Planetarium, College of Idaho, 2112 Cleveland, 83605, (208) 459-5011. Open by reservation only.

ILLINOIS

Champaign: William M. Staerkel Planetarium, Parkland College, 2400 West Bradley Ave., 61821, (217) 351-2568, 50' dome theater, Cinema 360, public observing. Open daily in summer. Program info. line: 351-2446.

Chicago: Museum of Science & Industry and Crown Space Center, 57th St. & Lake Shore Dr., 60637, (312) 684-1414, exhibits, OMNIMAX® theater. Open daily.

Chicago: The Adler Planetarium, 1300 South Lake Shore Dr., 60605, (312) 322-0304, 68' dome theater, exhibits, observatory (20" telescope with CCD). Open daily in summer.

Evanston: Dearborn Observatory, Northwestern University, 2131 Sheridan Road, 60201, (708) 256-6639, 18" telescope. Public observing Fri. evenings only by reservation.

Joliet: Herbert Trackman Planetarium, Joliet Junior College, 1216 Houbolt Ave., 60436, (815) 729-9020. Not open in summer.

Kankakee: Strickler Planetarium, Olivet Nazarene College, 60901, (815) 939-5267, 30' dome theater. Open by reservation.

Normal: Planetarium, Physics Department, Illinois State University, 61761-6901, (309) 438-8756, 30' dome theater, laser shows, public observing. Open Mon. & Wed. evenings only. Program info. line: 438-2496.

Peoria: Lakeview Museum of Arts and Sciences, 1125 West Lake Ave., 61614, (309) 686-7000, 33' dome planetarium, exhibits. Program info. line: 686-NOVA.

River Grove: Cernan Earth & Space Center, Triton College, 2000 Fifth Ave., 60171, (312) 456-5815, exhibits, 44' dome planetarium, laser shows, Cinema 360, public observing. Open daily in summer.

Rockford: Discovery Center Museum, 711 North Main St., 61103-6903, (815) 963-6769.

Rockford: The Time Museum, 7801 East State St., 61108, (815) 398-6000, extensive exhibits of historic timekeeping pieces, tours, films. Open Tues.–Sun. daytime.

Urbana: University of Illinois Observatory, 349 Astronomy Building, 1011 N. Springfield Ave., 61801, (217) 338-3090, 12" refractor.

INDIANA

Evansville: Koch Planetarium, Evansville Museum, 411 SE Riverside Dr., 47713, (812) 425-2406, 30' dome theater. Open Tues.–Sun.

Evansville: Wahnseidler Observatory, P.O. Box 3474, 47733, (812) 922-5681, 14" telescope. Located in Lynnville City Park. Open each Wed. & 3rd Fri.

Fort Wayne: E. C. Schouweiler Planetarium, Saint Francis College, 2701 Spring St., 46806.

Greencastle: McKim Observatory, DePauw University, 46135, (317) 658-4654, 9.5" Clark refractor. Open by reservation. Program info. line: 658-4661.

Indianapolis: Holcomb Observatory & Planetarium, Butler University, 4600 Sunset Ave., 46208, (317) 283-9282, 24' dome theater, exhibits, observatory (38" reflector). Open Fri. & Sat. Program info. line: 283-9333.

Indianapolis: Spacequest Planetarium, Children's Museum of Indianapolis, 3000 North Meridian St., 46208, (317) 924-5431, 40' dome theater with Digistar projector, exhibits. Open daily.

Marshall: Nature Center Planetarium, Turkey Run State Park, RR 1, Box 164, 47859, (317) 597-2654, 16' dome theater. Open daily in summer.

Muncie: Ball State University Planetarium, Department of Physics and Astronomy, 47306, (317) 285-8860. Open Mon.–Fri.

Terre Haute: John. C. Hook Memorial Observatory, Dept. of Geology and Geography, Indiana State Univ., 47802, (812) 237-6300. Open Tues. & Fri. evenings.

IOWA

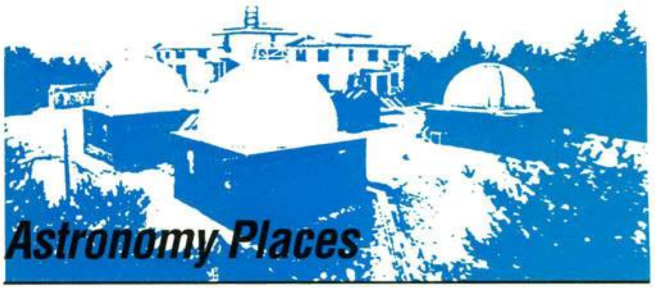
Cedar Falls: Hillside Observatory, University of Northern Iowa, Department of Earth Sciences, 50614, (319) 273-2759, 16" telescope. Open Thurs. evenings only Sept.–April.

Cherokee: Sanford Museum and Planetarium, 117 East Willow St., 51012, (712) 225-3922, 18' dome theater, exhibits. Open last Sun. of each month.

Des Moines: Drake Univ. Observatory, Drake Univ., 50311, (515) 271-3141. Open Fri. evenings.

Des Moines: The Science Center of Iowa/Sargent Planetarium, 4500 Grand Ave., 50312, (515) 274-4138, 40' dome theater with Digistar projector, exhibits. Open daily, daytime only.

Dubuque: Heitkamp Memorial Planetarium, Loras College, Dept. of Physics, 52001, (319) 588-7100. Open Fri. evenings. Not open in summer.



Astronomy Places

Waterloo: Grout Museum of History and Science, 503 South St., 50701, (319) 234-6357, exhibits, 15' dome planetarium. Open Tues.–Sat. after Museum re opening in August.

KANSAS

Great Bend: Barton County Community College Planetarium, Bissells Point Road, 67530, (316) 792-2701. Open by reservation only.

Greensburg: Pallasite Meteorite, The Big Well, 315 South Sycamore, 67054, (316) 723-2261. Open daily.

Hutchinson: Kansas Cosmosphere & Space Center, 1100 North Plum St., 67501, (316) 662-2305, 30' dome theater, OMNIMAX®, exhibits. Open daily in summer.

Topeka: Washburn University Planetarium, 17th & College, 66621, (913) 295-6330, 20' dome theater, observatory (12" refractor). Open by reservation.

Wichita: Lake Afton Public Observatory, 1845 Fairmount, 67208, (316) 689-3191. 16" telescope. Open Fri., Sat. & Sun. evenings, June-Aug. Program info. line: 794-8995

Wichita: Omnisphere and Science Center, 220 South Main St., 67202, (316) 264-3174, 30' dome theater. Open Tues.–Sun. Program info. line: 264-6178.

KENTUCKY

Berea: Weatherford Planetarium, Berea College, CPO 2326, 40404, (606) 986-9341, 30' dome theater, observatory with 16" telescope. Open Sat. & Sun. afternoons only.

Georgetown: Georgetown College Planetarium, 400 E. College St., 40324-1696, (502) 863-8436, 35' dome theater. Open by reservation only.

Louisville: Museum of History & Science, 727 West Main St., 40202, (502) 561-6103, exhibits, IMAX® theater. Open daily.

Louisville: Rauch Memorial Planetarium, University of Louisville, Belknap Campus, 40292, (502) 588-6665, 30' dome theater. Open Sat. afternoons.

Richmond: Hummel Planetarium, Eastern Kentucky University, 40475, (606) 622-1547, 67' dome theater. Open daily.

LOUISIANA

Baton Rouge: Louisiana Arts and Science Center Planetarium, 502 North Blvd., 70821, (504) 344-9465. Open Tues.–Sun.

Kenner: Freeport McMoran Daily Living Science Center, 409 Williams Blvd., 70062, (504) 468-7229, 26' dome planetarium, exhibits, observatory (14" SCT). Open daily in summer.

Lafayette: Lafayette Natural History Museum and Planetarium, 637 Girard Park Dr., 70503, (318) 268-5544, 30' dome theater, public observing. Open daily.

Luling: St. Charles Parish Library and Planetarium, 91 Lakewood Dr., 70070, (504) 785-8471, 20' dome theater, public observatory. Open Mon.–Sat.

New Orleans: Louisiana Nature and Science Planetarium, Joe W. Brown Memorial Park, P.O. Box 870610, 70187, (504) 246-STAR, exhibits, public observing, laser shows. Open Tues.–Sun.

MAINE

Easton: Francis Malcolm Science Center Planetarium, P.O. Box 186, U.S. Route 1-A, 04740, (207) 488-5451, 24' dome theater. Not open in summer.

Lewiston: Planetarium, Bates College, Dept. of Physics & Astronomy, 04240, (207) 786-6320.

Orono: University of Maine Planetarium, Wingate Hall, 04469, (207) 581-1341, 20' dome theater, observatory with 8" Clark refractor. Open by reservation only.

Portland: Southworth Planetarium, 96 Falmouth St., 04103, (207) 780-4249, 30' dome theater, exhibits, laser shows, public observing. Open Mon.–Sat. Astronomy Hotline: 780-4719.

MARYLAND

Annapolis: McKeldin Memorial Planetarium, St. John's College, 60 College Ave., 21401, (301) 263-2371, 24' dome theater.

Baltimore: Community College of Baltimore Planetarium, 2901 Liberty Heights Ave., 21215, (301) 396-7994. Open by reservation.

Baltimore: Maryland Science Center, Davis Planetarium, 601 Light St., 21230, (301) 685-2370, 50' dome theater, IMAX® theater, exhibits. Open daily in summer.

Baltimore: Space Telescope Science Institute, 3700 San Martin Drive, 21218, (301) 338-4700. Open by reservation only for tours.

College Park: University of Maryland Observatory, 1205 Space Sciences Building, 20742, (301) 454-3001, 20" scope. Open 5th & 20th of each month at 9 p.m.

Frostburg: Planetarium, Frostburg State University, 21532, (301) 689-4270. Open by reservation.

Greenbelt: NASA Goddard Space Center, Code 224, 20771, (301) 286-8981, Visitor Cneter, exhibits, tours. Open Wed.-Sun.

Hagerstown: Washington County Planetarium, 823 Commonwealth Ave., 21740, (301) 791-4172, 30' dome theater, public observing. Not open in summer.

Takoma Park: Montgomery College Planetarium, Takoma Ave. & Fenton St., 20912, (301) 650-1463, 24' dome theater. Open by reservation only.

MASSACHUSETTS

Amherst: Bassett Planetarium and Wilder Observatory, Amherst College, Department of Astronomy, 01002, (413) 542-2138, observatory (18" Clark refractor). Open Sun. afternoons. Public observing Sat. nights.

Amherst: Orchard Hill Observatory, Univ. of Massachusetts, 01002, (413) 545-0111, 20" Cassegrain. Open by reservation only.

Boston: Boston University Department of Astronomy Observatory, 725 Commonwealth Ave., College of Liberal Arts, 02215, (617) 353-5700, 14" & 12" telescopes. Open every clear Wed. night. Call 353-2630 after 5:30 p.m. Wed. to confirm.

Boston: Charles Hayden Planetarium, Boston Museum of Science, 02114-1099, (617) 589-0270, 60' dome planetarium, laser shows, exhibits, OMNIMAX® theater. Open daily in summer. Program info. line: 723-2500.

Cambridge: Harvard-Smithsonian Center for Astrophysics, 60 Garden St., 02138, (617) 495-7461, 9" Clark refractor. Public observing on third Thurs. evening each month. Sky info. line: 491-1497.

Cambridge: Wallace Observatory, Massachusetts Institute of Technology, Building 54-426, 02139, (617) 253-7568, 24" telescope. Open by reservation only.

Fall River: Bristol Community College Planetarium, 777 Elsbree St., 02720, (508) 678-2811. Open by reservation only.

Nantucket: Maria Mitchell Association, 2 Vestal St., 02554, (508) 228-9198, public observing Wed. evenings July & Aug. only. Program info. line: 228-9273.

Quabbin: Five College Radio Observatory, University of Massachusetts, Amherst, (413) 545-0111, 14-meter radio telescope. Open by restricted reservation.

Springfield: Springfield Science Museum, 236 State St., 01103, (413) 733-1194, exhibits, 33' dome planetarium, observatory (20" reflector). Open afternoons only, Thurs.–Sun.

Wenham: Woodside Planetarium and Observatory, 13 Friend Court, 01984, (508) 468-4815, 14' dome theater, observatory (14" SCT). Open by reservation.

Westford: Haystack Observatory, Rt. 40, 01886, (617) 692-4764.

Whatley: Whatley Observatory, University of Massachusetts, (413) 545-0111, 20" infra-red Cassegrain telescope. Open by restricted reservation.

Williamstown: Hopkins Observatory/Milham Planetarium, Main St., 01267, (413) 597-2105, 20' dome theater, observatory (14" telescope). Open Tues. & Thurs. evenings only. Program info. line: 597-2188.

Worchester: New England Science Center, 222 Harrington Way, 01604, (617) 791-9211, 40' dome planetarium, observatory (14" telescope). Open daily.

MICHIGAN

Alpena: Jesse Besser Museum and Planetarium, 491 Johnson St., 49707, (517) 356-2202, 33' dome theater, exhibits. Open daily in summer, daytime only.

Ann Arbor: Exhibit Museum Planetarium, 1109 Geddes Ave., 48109-1079, (313) 747-1381, 18' dome theater, exhibits. Open Tues.–Sun. Program info. line: 764-0478.

Battle Creek: Gardner Memorial Planetarium, Kingman Museum of Natural History, West Michigan Ave. at 20th St., 49017, (616) 965-5117, exhibits, 16' dome planetarium, public observing. Open daily in summer.

Bloomfield Hills: Cranbrook Institute of Science, 500 Lone Pine Road, P.O. Box 801, 48013, (313) 645-3235. McMath Planetarium (30' dome), Hulbert Observatory (6" refractor). Open daily in summer.

Detroit: Children's Museum/Detroit Public Schools, 67 East Kirby, 48202, (313) 494-1210, exhibits, planetarium shows. Open daily.

Detroit: Detroit Science Center, 5020 John R St., 48202, (313) 577-8430, exhibits, planetarium shows, laser shows, OMNIMAX® theater, public observing. Open Tues.–Sun.

East Lansing: Abrams Planetarium, Michigan State Univ., 48824-1324, (517) 355-4676, 50' dome theater, exhibits, observatory (24" telescope). Open daily in summer. Closed this August. Program info. line: 355-4672.

Flint: Robert T. Longway Planetarium, 1310 East Kearsley St., 48503, (313) 762-1181, 60' dome theater. Open daily.

Grand Rapids: Roger B. Chaffee Planetarium, Grand Rapids Public Museum, 233 Washington S.E., 49503, (616) 456-3985, 30' dome theater, laser shows, exhibits, public observing. Open daily in summer. Program info. line: 456-3200.

Kalamazoo: Kalamazoo Public Museum Planetarium, 315 South Rose St., 49007, (616) 345-7092, 30' dome theater, exhibits. Open Tues.–Sat. Program info. line: 382-6873.

Lansing: Impression Five Science Museum, 200 Museum Dr., 48933, (517) 485-8116, interactive exhibits. Open daily.

Lansing: Lansing Community College Planetarium, 419 N. Capitol Ave., 48910, (517) 373-7284, 39' dome theater, observatory (10" telescope), exhibits. Open by reservation only.

Lowell: James C. Veen Observatory, 3308 Kissing Rock Road SE, 49331, (616) 897-7065. Variety of telescopes for public viewing 2nd Sat. & last Fri., Apr.–Oct. Open House Week Aug. 18–24.

Marquette: Shiras Planetarium, 1203 West Fair Ave., 49855, (906) 225-4250, 30' dome theater. Open Mon. & Wed. only. Program info. line: 225-4204.

Mount Pleasant: Brooks Observatory, Physics Department, Central Michigan University, 48859, (517) 774-3321, 14" telescope. Open one Thurs. evening per month during academic year.

Muskegon: Carr-Fles Planetarium, Muskegon Community College, 221 S. Quarterline Road, 49442, (616) 777-0289, 24' dome theater. Not open in summer.

MINNESOTA

Duluth: Alworth Planetarium, Univ. of Minnesota–Duluth, 55812, (218) 726-7129, 32' dome theater. Open Wed. evenings only. Hosting Northern Nights '90, free day of astronomy activities and viewing, Sept. 7.

Hibbing: Paulucci Space Theater, Arrowhead Community College Region, Hwy 169 & East 23rd St., 55746, (218) 262-6718, 40' dome theater, Cinema 360 films. Open daily in summer. Program info. line: 262-6720.

Marshall: Planetarium, Southwest State University, 56258, (507) 537-6178, 30' dome theater. Open weekdays by reservation during academic year only.

Minneapolis: Minneapolis Planetarium, 300 Nicollet Mall, 55401, (612) 372-6543, 40' dome theater, laser shows. Open daily.

Moorhead: Moorhead State University Planetarium, 8th Ave. & 11th St. S, 56563, (218) 236-3982, 30' dome theater, monthly public observing. Open Thurs. evenings & by reservation.

New Ulm: Dr. Martin Luther College, 1884 College Heights, 56073, (507) 354-8221, 12' dome theater, observatory (17" telescope) Open daily.

St. Cloud: Observatory and Planetarium, St. Cloud State University, 56301, (612) 255-2011. Open by reservation only.

St. Paul: Planetarium, Macalester College, 1600 Grand Ave., 55105, (612) 696-6000, 22' dome theater, observatory (25" telescope). Not open to public.

St. Paul: Science Museum of Minnesota/McKnight Omnitheater, 30 E. 10th St., 55101, (612) 291-9403, exhibits, OMNIMAX® theater. Open daily.

MISSISSIPPI

Bay St. Louis: NASA John C. Stennis Space Center, 39529, (601) 688-2370. Visitor Center, exhibits, tours. Open daily 9 a.m.-5 p.m.

French Camp: Rainwater Observatory and Planetarium, French Camp Academy, 39745, (601) 547-6113, observatory (21" reflector, 20'). Open by reservation.

Jackson: Ronald E. McNair Space Theater, Russell Davis Planetarium, 201 East Pascagoula St., 39201, (601) 960-1550, 62' dome theater, laser shows, Cinema 360, exhibits. Open daily.

Oxford: Kennon Observatory, University of Mississippi, Department of Physics and Astronomy, 38677, (601) 232-7046, 15" refractor. Open by reservation.

MISSOURI

Kansas City: Kansas City Museum Planetarium, 3218 Gladstone Blvd., 64123, (816) 483-8300, 24' dome theater, exhibits. Open daily in summer. Program info. line: 483-STAR.

St. Louis: St. Louis Science Center, 5100 Clayton Road, Forest Park, 63110, (314) 289-4400, 60' dome theater, exhibits, public observing. Open daily.. Program info. line: 289-4444.

MONTANA

Bozeman: Taylor Planetarium, Museum of the Rockies, Montana State University, 59717, (406) 994-2251, 40' dome theater with Digistar projector, public observing. Open daily in summer.

NORTH CAROLINA

Chapel Hill: Morehead Planetarium, University of North Carolina, CB 3480, 27599, (919) 962-1236, 68' dome theater, Cinema 360, exhibits, observatory (24" reflector). Open daily in summer. Program info. line: 962-1248.

Charlotte: Discovery Place/Nature Museum, 301 North Tryon St., 28202, (704) 372-6261, 24' dome planetarium. Open daily. New Planetarium/OMNIMAX® theater opens Oct. 91.

Durham: North Carolina Museum of Life & Science, 433 Murray Ave., P.O. Box 15190, 27704, (919) 477-0431, exhibits, space artifacts. Open daily in summer.

Greensboro: Edward Zane Planetarium, The Natural Science Center, 4301 Lawndale Dr., 27408, (919) 288-3769, 40' dome theater, exhibits, solar observatory. Open daily in summer.

Greensboro: Three College Observatory, Department of Physics & Astronomy, University of North Carolina, 27412, (919) 334-5844. Open by reservation only. Not open in July & Aug.

Hickory: Catawba Science Center, 243 3rd Ave. NE, P.O. Box 2431, 28603, (701) 322-8169. Open Tues.–Sun.

Hudson: Planetarium, Caldwell Community College, 1000 Hickory Blvd., 28638, (704) 726-2200, 20' dome theater. Open by reservation only.

Lumberton: Robeson Science & Technology Center, Hwys. 72 & 711, P.O. Drawer 2909, 28359, (919) 739-3302, planetarium shows. Not open in summer.

Rocky Mount: Rocky Mount Planetarium, Children's Museum, 1610 Gay St., 27804, (919) 972-1167. Open by reservation.

Salisbury: Margaret C. Woodson Planetarium, 1636 Parkview Circle, 28144, (704) 636-3462, exhibits, observatory. Open Mon.–Fri. & by reservation on Sat. and Sun. evenings.

Winston-Salem: Nature Science Center/Hanes Planetarium, Museum Dr., 27104, (919) 767-6730, 20' dome theater, exhibits. Open daily in summer.

NORTH DAKOTA

Grand Forks: University of North Dakota Atmospherium, Center for Aerospace Studies, P.O. Box 8216, University Station, 58202, (701) 777-2184, exhibits, planetarium shows. Open Thurs.-Sun.

Minot: Minot State University Observatory, 500 University Ave. West, 58701, (701) 857-3071, 16" telescope. Open occasional Thurs. evenings.

Valley City: Planetarium, Valley City State University, 58072, (701) 845-7334, 24' dome theater. Open by reservation only.

NEBRASKA

Chadron: Planetarium, Chadron State College, 10th & Main St., 69337, (308) 432-6236, 25' dome theater, exhibits. Open by reservation only.

Fremont: Lueninghoener Planetarium, Midland Lutheran College, 900 N. Clarkson, 68025, (402) 721-5480, 30' dome theater, observatory (11" telescope). Open by reservation only.

Hastings: J. M. McDonald Planetarium, 1330 North Burlington Ave., 68901, (402) 461-2399, 24' dome theater, exhibits, observatory (14" telescope). Open daily in summer.

Kearney: Bruner Hall of Science Planetarium, Kearney State College, 68849, (308) 234-8277, 24' dome theater, observatory (16" telescope). Open by reservation only.

Lincoln: Behlen Observatory, Dept. of Physics & Astronomy, University of Nebraska, 68588-0111, (402) 472-2788. Open for group reservations only.

Lincoln: Hyde Memorial Observatory, Holmes Park, Golf Course Road, 68506, (402) 471-7094, 14" scope. Open Sat. evenings.

Lincoln: Mueller Planetarium, University of Nebraska State Museum, 213 Morrill Hall, 68588-0338, (402) 472-2641, 34' dome theater, laser shows. Open daily.

Omaha: Durham Science Center and Kountze Planetarium, University of Nebraska at Omaha, 68th & Dodge St., 68182, (402) 554-3727, 33' dome theater, laser shows, observatory. Open Fri.–Sun. only.

NEVADA

Las Vegas: Planetarium, Community College of Southern Nevada, 3200 E. Cheyenne Ave., 89030, (702) 643-6060, 30' dome theater, Cinema 360, public observing. Open Thurs.–Sat. Program info. line: 644-5059.

Reno: Fleischmann Planetarium, University of Nevada, 1650 N. Virginia St., 89557, (702) 784-4812, 30' dome theater, Cinema 360, exhibits, public observing. Open daily in summer.

NEW HAMPSHIRE

Durham: University of New Hampshire Observatory, DeMeritt Hall, 03801, (603) 862-1950, 14" telescope. Open every other Fri. all year.

Hanover: Shattuck Observatory, Dartmouth College, Physics and Astronomy Dept., Wilder Hall, 03755, (603) 646-2034. Open by reservation only.

Plymouth: Planetarium, Plymouth State College, 03264, (603) 536-5000, 20' dome theater. Open daily in summer.

NEW JERSEY

Mountainside: Trailside Nature and Science Center, Coles Ave. & New Providence Road, 07092, (201) 789-3670, 20' dome planetarium. Open Sun. only.

Newark: Newark Museum Planetarium, 49 Washington St., 07101, (201) 596-6610, 30' dome theater, public observing. Open daily in summer.

Randolph: County College of Morris Planetarium, Route 10 & Center Grove Road, 07869, (201) 328-5755, 33' dome theater, public observing. Open by reservation.

Toms River: Robert J. Novins Planetarium, Ocean County College, 08754-2001, (201) 255-0343. Shows Fri., Sat. & Sun. until June 9. Shows Tues.–Fri. after July 9. Program info. line: 255-0342.

Trenton: New Jersey State Museum Planetarium, 205 West State St., CN 530, 08625, (609) 292-6333, 40' dome theater, exhibits. Open daily in summer, daytime only.

NEW MEXICO

Alamogordo: The Space Center/Tombaugh Space Theater, Top of Highway 2001, 88310, (505) 437-2840, 40' dome theater, OMNIMAX®, laser shows, exhibits. Open daily in summer.

Albuquerque: University of New Mexico Observatory, Institute for Astrophysics, 800 Yale Blvd. NE, 87131, (505) 277-2616. 12" Maksutov. Open by reservation. Not open in summer.

Roswell: Robert H. Goddard Planetarium, 11th & North Main, 88201, (505) 624-6744, 40' dome theater, exhibits, public observing. Open daily.

Socorro: Very Large Array, National Radio Astronomy Observatory, P.O. Box O, 87801-0387, (505) 835-7000, 27 element array of 85' dishes, exhibits. Open daily from 8:30 a.m. to sunset.

Sunspot: ARC Telescope, N. M. State University, Dept. of Astronomy, Box 30001, Dept. 45000, Las Cruces, 88003, (505) 646-4438. Open daily in summer.

Sunspot: National Solar Observatory, Sacramento Peak, 88349, (505) 434-7000, 64" telescope, guided tours every Sat. at 2pm. Open daily, daytime only.

NEW YORK

Alfred: Observatory, Alfred University, 14802, (607) 871-2208, 20" & 32" telescopes. Open clear Thurs. evenings May–July.

Binghamton: Roberson Center for the Arts and Sciences/Link Planetarium, 30 Front St., 13905, (607) 772-0660, 30' dome theater, laser shows, exhibits, observatory (14" & 12" scopes). Planetarium open Tues.–Sun.

Bronx: Northeast Bronx Planetarium, 750 Baychester Ave., 10475, (212) 379-1616, 40' dome theater. Open by reservation only. Not open in summer.

Brooklyn: Edwin P. Hubble Planetarium, 1600 Ave. L, 11230, (718) 258-9283, 24' dome theater. Not open in summer.

Buffalo: Ferguson Planetarium, Buffalo State Collage, 1300 Elmwood Ave., 14222, (716) 878-4911, 24' dome theater, public observing. Open by reservation.

Centerport: Vanderbilt Planetarium, 180 Little Neck Road, 11721, (516) 262-7800, 60' dome theater, exhibits, observatory (16" Cassegrain). Open daily. Program info. line: 262-STAR.

Geneseo: Observatory at SUNY College, Department of Physics & Astronomy, 209 Greene Science Building, 14454, (716) 245-5282, 14" telescope. Open Fri. evenings by reservation only. Not open in summer.

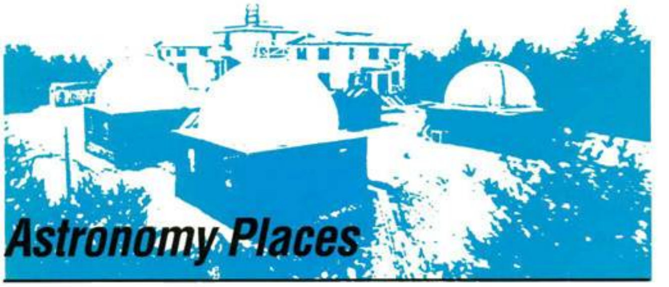
Herkimer: Herkimer County BOCES Planetarium, 400 Gros Blvd., 13350, (315) 867-2023, 33' dome theater, mobile solar video observatory. Open Mon.–Fri. by reservation only.

Ithaca: Cornell University Observatory, Dept. of Astronomy, Space Sciences Bldg., 14853, (607) 255-4935, 14" & 12" telescopes. Public observing Fri. evenings.

Middle Island: Longwood District Planetarium, Middle Island – Yaphank Road, 11953, (516) 345-2741. Not open in summer.

New Paltz: John R. Kirk Planetarium, State University College, CSB 28, 12561, (914) 257-3818, 24' dome theater, observatory (8" telescope). Open by reservation only. Not open in summer.

New York: American Museum/Hayden Planetarium, Central Park West at 81st St., 10024-5192, (212) 769-5900, 75' dome



Astronomy Places

theater, exhibits, laser shows. Open daily in summer.

New York: New York Hall of Science, 47-01 111th St., Corona, 11368, (718) 699-0005, exhibits, laser demos, Starlab planetarium. Open daily.

New York: Planetarium, City College of New York, Science & Physics Building, 10031, (212) 650-6832, 30' dome theater. Open by reservation only.

Poplar Ridge: Southern Cayuga Planetarium, Route 34B, 13139, (315) 364-7111, 30 dome theater, exhibits, public observing. Open by reservation only.

Potsdam: Potsdam College Planetarium, Pierrepont Ave., 13676, (315) 267-2284. Open by reservation only.

Rochester: C.E.K. Mees Observatory, University of Rochester, Department of Physics and Astronomy, 14627, (716) 275-0539, 24" telescope. Tours Fri. & Sat. evenings by reservation only.

Rochester: Strasenburgh Planetarium, Rochester Museum and Science Center, 657 East Ave., Box 1480, 14603-1480, (716) 271-4320, 65' dome theater, laser shows, exhibits, observatory (12.5" telescope). Open daily. Program info. line: 442-7171.

Schenectady: Schenectady Museum and Planetarium, Nott Terrace Heights, 12308, (518) 382-7890, 30' dome theater, laser shows, observing. Open Tues.–Sun.

Staten Island: Wagner College Planetarium, 631 Howard Ave., Grymes Hill, 10301, (718) 390-3432. Open by reservation only.

Syracuse: Discovery Center of Science and Technology, 321 South Clinton St., 13202, (315) 425-9068, exhibits, 20' dome planetarium, public observing. Open Tues.–Sun. Program info. line: 425-0747.

Troy: The Junior Museum, 282 5th Ave., 12182, (518) 235-2120, exhibits, planetarium shows. Open Mon.–Wed. and Sat. & Sun.

Yonkers: Andrus Planetarium, 511 Warburton Ave., 10701, (914) 963-4550, 40' dome theater, observing. Open Wed.–Sun.

OHIO

Bay Village: Schuele Planetarium, 28728 Wolf Road, 44140, (216) 835-9912, Open Sun. only.

Canton: Hoover-Price Planetarium, McKinley Museum, 800 McKinley Monument Dr., 44701, (216) 455-7043, 25' dome theater, exhibits. Open daily in summer.

Cincinnati: Cincinnati Museum of Natural History and Planetarium, 1720 Gilbert Ave., 45202, (513) 621-3889. Open Tues.–Sun.

Cincinnati: Cincinnati Observatory, 3489 Observatory Place, 45208, (513) 321-5186, 16" & 11" refractors. Open by reservation.

Cleveland: Cleveland Museum of Natural History, 1 Wade Oval Drive, University Circle, 44106, (216) 231-4600, Mueller Planetarium (30' dome), exhibits, observatory (10.5" refractor). Open daily in summer.

Cleveland: NASA Lewis Research Center, 21000 Brookpark Road MS 8-1, 44135, (216) 433-2001, Visitor Center. Open daily.

Cleveland: Warner & Swasey Observatory, Case Western Reserve Univ., 44106, (216) 368-3728.

Columbus: Center of Science and Industry, 280 East Broad St., 43215, (614) 228-2674, exhibits, Batelle Planetarium (30' dome). Open daily, daytime only.

Columbus: Ohio State University Planetarium, 174 West 18th Ave., 43210, (614) 292-5554, 26' dome theater.

Dayton: Dayton Museum of Natural History, 2629 Ridge Ave., 45414, (513) 275-7431, 30' dome planetarium, exhibits, observatory (20" telescope). Open daily. New 50' dome Digistar Sky Theater opens Oct. 5.

Delaware: Perkins Observatory, P.O. Box 449, 43015, (614) 363-1257, 32" reflector. Located on Route 23, 3 miles south of Delaware. Open Mon.–Fri. afternoons only. Open one evening per month, June–Oct.

Granville: Swasey Observatory, Denison University, 43023, (614) 587-6311, 9" telescope. Tours Mon.–Fri. mornings. Open evenings by reservation only.

Kent: Planetarium, Physics Department, Kent State University, 44242, (216) 672-2771, 40' dome theater. Open by reservation only.

Sylvania: Copernicus Planetarium, Lourdes College, 6832 Convent Blvd., 43560-2898, (419) 885-3211, 24' dome theater, exhibits, public observing. Open Mon.–Sat. during academic year. Not open in summer.

Toledo: Ritter Planetarium and Brooks Observatory, University of Toledo, 2801 W. Bancroft St., 43606, (419) 537-4641, 40' dome theater, observatory (1-meter telescope), exhibits. Open Fri., Sat, & Sun.

Westerville: North American Astrophysical Observatory, Otterbein College, 43081, (614) 898-1516, 320' by 71' radio telescope. Open by reservation only.

Wilmot: Wilderness Center Planetarium, 9877 Alabama Ave., S.W., P.O. Box 202, 44689, (216) 359-5235, 12' dome theater, public observing. Center open Tues.–Sun. daytime only.

Youngstown: Ward Beecher Planetarium, Youngstown State University, 44555-0001, (216) 742-3136, 40' dome theater, laser shows, observatory (14" telescope). Open by reservation.

OKLAHOMA

Fort Sill: Fort Sill Planetarium, Target Acquisition Department, 73503, (405) 351-6616, Only planetarium in the Army. Open by reservation only.

Oklahoma City: Kirkpatrick Planetarium, OMNIPLEX Science Museum, 2100 N.E. 52nd, 73111, (405) 424-5545, 40' dome theater, exhibits, observatory (16" telescope). Open daily.

OREGON

Bend: Pine Mountain Observatory, University of Oregon, Bend-Burns Star Route, 97702, (503) 382-8331, 32" & 24" telescope. Open by reservation only.

Gresham: Mt. Hood Community College Planetarium, 26000 S.E. Stark St., 97030, (503) 667-7297, 30' dome theater, observatory (6" solar telescope). Planetarium closed June–Sept.

Portland: Oregon Museum of Science & Technology/Kendall Planetarium, 4015 SW Canyon Road, 97221, (503) 222-2828, 40' dome theater, laser shows, public observing. Open daily. Program info. line: 228-STAR.

Salem: Chemetka Community College Planetarium, 4000 Lancaster Dr., N.E., P.O. Box 14007, 97309, (503) 399-5761. Open Fri. & Sat. only.

PENNSYLVANIA

Clarion: Pierce Planetarium, Clarion University, 16214, (814) 226-1881, 40' dome theater, exhibits, public observing. Open by reservation. Not open in summer.

Edinboro: Observatory and Planetarium, Edinboro Univ., 16444, (814) 732-2493, 24' dome theater, observatory (14" Cassegrain). Open by reservation only.

Erie: Erie Historical Museum and Planetarium, 356 West 6th St., 16507, (814) 453-5811. Open Tues.–Sun.

Harrisburg: State Museum of Pennsylvania Planetarium, 3rd & North Streets, 17108, (717) 783-9914. Open daily in summer.

Lancaster: North Museum Planetarium, Franklin & Marshall College, P.O. Box 3003, 17604-3003, (717) 291-3941, 40' dome theater, exhibits, observatory (11" refractor & 16" reflector). Open Wed.–Sun. only. Program info. line: 291-4315.

Latrobe: Observatory, St. Vincent College, 15650, (412) 539-9761. Public observing Sun. nights only by reservation.

Lewisburg: Bucknell University Observatory, Department of Physics, 17837, (717) 524-1207, 10" refractor. Open by reservation.

Lock Haven: Ulmer Planetarium, Lock Haven University, 17745, (717) 893-2075, 30' dome theater. Open by reservation only. Not open in summer.

New Wilmington: Westminster College Planetarium, 16172, (412) 946-7200, 24' dome theater, observatory (14" telescope). Open by reservation only.

Philadelphia: Franklin Institute, 20th & the Parkway, 19103, (215) 448-1157, Fels Planetarium (65' dome), Tuttleman Omniverse Theater (76' dome), observatory (24" Fecker reflector & 10" Zeiss refractor). Open daily. Program info. line: 448-1200.

Philadelphia: University of Pennsylvania Observatory, Astronomy Dept., David Rittenhouse Laboratory, 33rd & Walnut St., 19104, (215) 898-8176. Open Mon. & Thurs. evenings only.

Pittsburgh: Allegheny Observatory, 159 Riverview Ave., 15214, (412) 321-2400.

Pittsburgh: Buhl Science Center, Allegheny Square, 15212, (412) 237-3345, 65' dome theater, laser shows, observatory (10" refractor). Closes Aug. 31. Program info. line: 237-3300.

Pittsburgh: Carnegie Science Center, One Allegheny Square, 15212, 50' dome interactive theater, OMNIMAX® theater, laser shows, exhibits, observatory (16" reflector). Opens Oct. 5.

Reading: Reading School District Planetarium, 1211 Parkside Dr. South, 19611-1441, (215) 371-5854, 40' dome theater, exhibits. Open Mon.–Fri. afternoons only.

Scranton: Everhart Museum Planetarium, Nay Aug Park, 18510, (717) 346-8370, Open Tues.–Fri. by reservation.

Villanova: Villanova University Observatory, Mendel Hall, 19085, (215) 645-4820, 14" telescope. Open by reservation only.

West Chester: West Chester State University Planetarium, Department of Geology & Astronomy, Rosedale & South Church Streets, 19383, (215) 436-2721, 33' dome planetarium, observatory (12" telescope). Open by reservation only.

RHODE ISLAND

Charlestown: Frosty Drew Observatory, Ninigret Park, P.O. Box 160, 02813, (401) 364-9508, 7" refractor. Open Fri. evenings.

Middletown: Middletown Planetarium, Gaudet School, Aquidneck Ave., 02840, (401) 846-6395, 30' dome theater, public observing. Open by reservation only.

Providence: Cormack Planetarium, Museum of Natural History, Roger Williams Park, 02908, (401) 785-9450, 26' dome theater. Open Sat. & Sun. only.

Providence: Ladd Observatory, 210 Doyle Ave., 02912, (401) 521-5680, 12" Brashear refractor. Public observing Wed. evenings.

Warwick: Observatory, Community College of Rhode Island, 400 East Avenue, 02886, (401) 728-4171, 14" telescope. Not open in summer.

SOUTH CAROLINA

Columbia: Gibbes Planetarium, 1112 Bull St., 29201, (803) 799-2810, 26' dome theater. Open Sat. & Sun. Program info. line: 254-STAR.

Columbia: Melton Memorial Observatory, University of South Carolina, Dept. of Physics & Astronomy, 29208, (803) 777-6446. Open clear Mon. nights 9:30 to 11 p.m. 16" reflector.

Florence: Planetarium and Observatory, Francis Marion College, P.O. Box 100547, 29501-0547, (803) 661-1250, 33' dome theater, observatory (14" telescope). Open 2nd & 4th Sundays.

Greenville: Roper Mountain Science Center & Daniel Observatory, 504 Roper Mountain Road, 29615, (803) 281-1188, 50' dome planetarium with Digistar projector. 23" refractor. Open Fri. evenings & Sat. afternoons.

Orangeburg: Stanback Museum and Planetarium, P.O. Box 7636, 29117, (803) 536-8711. 40' dome theater. Open Mon.–Fri. days only.

Rock Hill: Settlemyre Planetarium, Museum of York County, 4621 Mt. Gallant Road, 29730, (803) 329-2121, 30' dome theater, public observing. Open daily.

TENNESSEE

Brentwood: Dyer Observatory, 1000 Oman Dr., 37027, (615) 373-4897, 24" telescope. Public nights June 20, July 11, Sept. 5, & Oct. 3.

Chattanooga: Clarence Jones Observatory, University of Tennessee at Chattanooga, Dept. of Physics and Astronomy, 37403, (615) 755-4546, 22.5" reflector, 35' dome planetarium. Open Fri. evenings only by reservation.

Kingsport: Bays Mountain Planetarium and Nature Center, 853 Bays Mountain Park Road, 37660, (615) 229-9447, 40' dome theater, laser shows, exhibits, observatory (8" refractor). Open daily in summer.

Knoxville: East Tennessee Discovery Center/Akima Planetarium, P.O. Box 6204, 516 Beaman St., 37914-0204, (615) 637-1121, 30' dome theater, exhibits. Open daily in summer, daytime only.

Memphis: Memphis Pink Palace Museum and Planetarium, 3050 Central Ave., 38111, (901) 320-6320, 50' dome theater, laser shows, public observing. Open Tues.–Sun.

Nashville: Campus Observatory, Vanderbilt University, P.O. Box 1803, Station B, 37235, (615) 373-4897, 6" telescope. Public nights June 12, June 26, Sept. 16, & Oct. 16.

Nashville: Sudekum Planetarium, Cumberland Science Museum, 800 Ridley Blvd., 37211, (615) 259-6383, exhibits, 40' dome planetarium, laser shows. Open daily in summer.

TEXAS

Amarillo: Don Harrington Discovery Center, 1200 Streit Dr., 79106, (806) 355-9547, 40' dome theater, Cinema 360, exhibits. Open daily in summer.

Dallas: Richland College Cosmic Theater & Planetarium, 12800 Abrams Road, 75243, (214) 238-6038, 40' dome theater, laser shows, public observing. Open Fri. & Sat. evenings and Sun. afternoons. Program info. line: 238-6013.

Dallas: St. Mark's School of Texas Planetarium, 10600 Preston Road, 75230, (214) 363-6491, 30' dome theater, laser shows, observatory (16" telescope). Open by reservation only.

Dallas: The Science Place Planetarium, P.O. Box 151469, 75315-1469, (214) 428-8351, 24' dome theater, exhibits. Open daily.

El Paso: El Paso Planetarium, 6531 Boeing Dr., 79935, (915) 779-4316, 40' dome theater, observing. Exhibits open daily in summer (shows by reservation only). Program info. line: 774-4317.

El Paso: Insights, El Paso Science Center, 303 N. Oregon St., 79901, (915) 542-2990.

Ft. Davis: McDonald Observatory, W. L. Moody Visitor's Center, P.O. Box 1337, 79734, (915) 426-3640, 107", 82", 36" & 30" telescopes. Open daily in summer. Public observing Tues., Fri. & Sat. evenings. Viewing through 107" on one Wed. per month near Full Moon.

Ft. Worth: Fort Worth Museum of Science & History, 1501 Montgomery St., 76107, (817) 732-1631, exhibits, 30' dome planetarium, laser shows, OMNI-MAX® theater, public observing. Open daily in summer.

Houston: Burke Baker Planetarium, Houston Museum of Natural Science, One Hermann Circle Dr., 77030, (713) 639-4632, 50' dome theater, laser shows, IMAX® theater, George Observatory (36") and Brown Observatory (16"). Open daily. Program info. line: 639-4600.

Houston: Lyndon B. Johnson Space Center, 2101 NASA Road 1, 77058, (713) 483-4321, exhibits, tours. Open daily. Opening this year: Space Center Houston.

Killeen: Planetarium, Central Texas College, P.O. Box 1800, Hwy, 190 West, 76540, (817) 526-1288, 24' dome theater, observatory. Open by reservation only.

Lubbock: Moody Planetarium, Museum of Texas Tech. University, 4th & Indiana Ave., 79409, (806) 742-2432, 30' dome theater. Open daily in summer.

Midland: Marian Blakemore Planetarium, Museum of the Southwest, 1705 W. Missouri, 79701-6516, (915) 683-2882, 40' dome theater, laser shows. Closed this summer; reopening this fall.

Nacogdoches: Stephen Austin State University Planetarium, P.O. Box 13044, SFA Station, 75962, (409) 568-3001, 30' dome theater, observatory (1 meter telescope). Open Fri. evenings only Sept. to May.

Odessa: Odessa Meteor Crater, c/o 1204 Texas Commerce Bank Building, 79761, (915) 332-1666, exhibits. Open daily.

San Angelo: Planetarium, Angelo State University, 76909, (915) 942-2136, 50' dome theater. Open Mon.–Fri. in summer.

San Antonio: San Antonio College Planetarium, 1300 San Pedro Ave., 78212, (512) 733-2910. Open Sun. evenings. Closed July 15–Aug. 30.

Tyler: Hudnall Planetarium, Tyler Junior College, P.O. Box 9020, 75711, (214) 531-2312, 30' dome theater, exhibits, public observing. Open 1st & 3rd Sundays in June & July.

Wichita Falls: Wichita Falls Museum & Art Center Planetarium, 2 Eureka Circle, 76308, (817) 692-0923, 26' dome theater. Open Sat. & Sun. only.

UTAH

Ogden: Layton Ott Planetarium, Weber State College, 84408, (801) 626-6855, 30' dome theater, exhibits, public observing. Open Wed. evenings only.

Provo: Sarah Summerhays Planetarium, Brigham Young University, Physics Department, 492 ESC, 84602, (801) 378-2805. Open Fri. evenings & by reservation.

Salt Lake City: Hansen Planetarium, 15 South State St., 84111, (801) 538-2104, Digistar projector, laser shows. Open daily.

VERMONT

Williston: Green Mountain Observatory II, P.O. Box 782, 05495, (802) 985-3269. 10" telescope. Open by reservation only.

VIRGINIA

Arlington: Arlington Planetarium, 1426 North Quincy St., 22207, (703) 358-6070, 30' dome theater. Not open in summer.

Ashland: Keeble Observatory, Randolph-Macon College, 23005, (804) 752-7344, 12" telescope. Open by reservation only.

Charlottesville: Leander McCormick Observatory, University of Virginia, P.O. Box 3818, 22903, (804) 924-7494, 26" Clark refractor. Public observing 1st & 3rd Fri. of each month through summer.

Chesapeake: Chesapeake Planetarium, 300 Cedar Road, 23320, (804) 547-0153, 30' dome theater, observatory (14" telescope). Open Thurs. evenings.

Hampton: NASA Langley Visitor Center, Mail Stop 480, 23665, (804) 864-6000. Visitor Center, tours by reservation. Open daily.

Harrisonburg: John C. Wells Planetarium, James Madison University, Dept. of Physics, 22807, (703) 568-6109. 30' dome theater, observatory (14" telescope). Open Thurs. evenings. Program info. line: 568-STAR.

Harrisonburg: M.T. Brackbill Planetarium, Eastern Mennonite College, 22801, (703) 432-4400, 30' dome theater, observatory (8" telescope). Open by reservation only. Not open in summer.

Newport News: Virginia Living Museum Planetarium, 524 J. Clyde Morris Blvd., 23601, (804) 595-1900, 30' dome planetarium, observatory (14" telescope). Open daily in summer.

Richmond: Science Museum of Virginia, Ethyl Universe Space Theater, 2500 West Broad St., 23220, (804) 367-0211, 76' dome theater with Digistar projector, OMNIMAX® films, public observing. Open daily. Program info. line: 367-8277.

Roanoke: Science Museum of Western Virginia/Hopkins Planetarium, Center in the Square, 24011, (703) 342-5714, 40' dome theater, Cinema 360, exhibits, laser shows, public observing. Open daily in summer. Program info. line: 342-7876.

Virginia Beach: Virginia Beach City Public Schools Planetarium, 3080 South Lynnhaven Road, 23452, (804) 431-4067, 40' dome theater, exhibits, public observing. Open Tuesday. & Sunday evenings only. Closed this July.

Wallops Island: NASA Wallops Flight Facility, 23337, (804) 824-1344, Visitor Center, exhibits, tours by reservation. Open daily in summer, daytime only.

WASHINGTON

Bellingham: Western Washington University Planetarium, Physics Department, 98225, (206) 676-3820, 24' dome theater. Open by reservation only.

Goldendale: Goldendale Observatory State Park, 1602 Observatory Dr., 98620, (509) 773-3141, 24.5" telescope plus 2" to 18" portables. Open daily.

Seattle: Pacific Science Center, 200 Second Avenue North, 98109, (206) 443-2001, exhibits, 27' dome planetarium, laser shows, IMAX® theater. Open daily. Astronomy Hotline: 443-2920.

Spokane: Eastern Washington Science Center, Riverfront Park, 99202, (509) 359-6391, exhibits, planetarium shows. Open daily.

WEST VIRGINIA

Charleston: Sunrise Children's Museum Planetarium, 746 Myrtle Road, 25314, (304) 344-8035, 24' dome theater, exhibits, public observing. Open Fri. & Sat.

Elkins: Flynn Planetarium, Davis and Elkins College, 26241, (304) 636-1900, 25' dome theater. Open by reservation only.

Green Bank: National Radio Astronomy Observatory, P.O. Box 2, 24944, (304) 456-2011, exhibits, tours. Open daily in summer.

Parkersburg: Dwight O. Connor Planetarium, 2101 Dudley Ave., Parkersburg High School, 26101, (304) 420-9595, 27' dome theater. Open by reservation.

Wheeling: Benedum Natural Science Center, Oglebay Resort and Conference Center, 26003, (304) 243-4034, 40' dome theater, laser shows, Cinema 360, observatory (10" SCT). Open daily.

WISCONSIN

Fall Creek: Hobbs Observatory, Route 2, Box 94, 54742, (715) 877-2787, 24" reflector. Open every Sat. night May to Oct.

Eau Claire: L. E. Phillips Planetarium, University of Wisconsin, 54701, (715) 836-5731, 24' dome theater. Not open this summer.

La Crosse: Planetarium, University of Wisconsin at La Crosse, Cowley Hall, 54601, (608) 785-8669.

Madison: UW Space Place, 1605 S. Park St., 53715, (608) 262-4779, public astronomy lectures and childrens' workshops.

Madison: Washburn Observatory, University of Wisconsin–Madison, 1401 Observatory Dr., 53706, (608) 262-3071, 15" refractor. Open 1st & 3rd Wed. evenings of the month & each Wed. June 19 to July 31. Call 262-WASH for update.

Menasha: Planetarium, University of Wisconsin–Fox Valley, 1478 Midway Road, 54952, (414) 832-2616. Open Sun. evenings.

Stevens Point: University of Wisconsin–Stevens Point Planetarium, 740 Reserve St., 54481, (715) 346-2208, 25' dome theater, observatory (16" telescope). Open Wed. evenings.

Williams Bay: Yerkes Observatory, 373 West. Geneva Street, P.O. Box 258, 53191, (414) 245-5555. Largest refractor (40") in the world. From June–September: open Sat. 1:30–3 p.m.; from October.–May: open Saturday. 10–11:15 a.m.

WYOMING

Casper: Casper Planetarium, 904 North Poplar St., 82601, (307) 557-0310, 30' dome theater, laser shows. Open daily.

Laramie: University of Wyoming Planetarium, Department of Physics and Astronomy, University Station, Box 3905, 82071, (307) 766-6150.

Laramie: Wyoming Infrared Observatory, University of Wyoming, University Station, Box 3905, 82071, (307) 766-6150.

Astronomy Places

CANADA

ALBERTA

Calgary: Alberta Science Centre, 701 - 11 St. SW, T2P 2M5, (403) 221-3713, 65' dome theatre, laser shows, exhibits, observatory (8" refractor). Open daily. Program info. line: 221-3700.

Calgary: Rothney Astrophysical Observatory, Dept. of Physics and Astronomy, Univ. of Calgary, 2500 Univ. Dr. NW, T2N 1N4, (403) 220-5392. 1.8-metre reflector. Open by reservation only.

Edmonton: Edmonton Space & Science Centre, 11211 - 142 St., T5M 4A1, (403) 452-9100, 76' dome planetarium, laser shows, IMAX® theatre, exhibits, observatory (14" SCT). Open daily. Program info. line: 493-9000.

Edmonton: Physics Department Observatory, University of Alberta, T6G 2J1, (403) 492-5287, 14" & 12" telescopes. Public viewing Fri. nights during school year. Not open in summer.

BRITISH COLUMBIA

Penticton: Dominion Radio Astrophysical Observatory, Box 248, V2A 6K3, (604) 497-5321, 26-metre radio dish, exhibits, guided tours Sun. 2–5 p.m. Open daily, daytime only. Program info. line: 497-5788.

Vancouver: H.R. MacMillan Planetarium & Gordon Southam Observatory, 1100 Chestnut St., V6J 3J9, (604) 736-4431, 65' dome theater, laser shows, observatory (20" telescope). Open daily. Program info. line: 736-3656.

Vancouver: Science World, 1455 Quebec St., V6A 3Z7, (604) 687-8414, exhibits, OMNIMAX® theatre. Open daily in summer. Program info. line: 687-7832.

Vancouver: University of British Columbia Observatory, 2219 Main Mall, V6T 1W5, (604) 228-2802, 16" telescope. Open clear Sat. evenings. Call 228-6186.

Victoria: Climenhaga Observatory, Department of Physics and Astronomy, University of Victoria, V8W 3P6, (604) 721-7750, 20" telescope. Open by reservation.

Victoria: Dominion Astrophysical Observatory, 5071 West Saanich Road, V8X 4M6, (604) 363-0001, 1.85-metre reflector, exhibits, public observing Sat. evenings. Open Mon.–Fri. daytime only.

MANITOBA

Winnipeg: Lockhart Planetarium, 380 University College, Univ. of Manitoba, 500 Dysart Road, R3T 2M8, (204) 474-9785, 8-metre dome. Open by reservation.

Winnipeg: Manitoba Planetarium, Museum of Man & Nature, 190 Rupert Ave., R3B 0N2, (204) 956-2830, 60' dome theatre, exhibits. Open daily. Program info. line: 943-3142.

NOVA SCOTIA

Halifax: Burke-Gaffney Observatory, Saint Mary's University, B3H 3C3, (902) 420-5633, 16" telescope. Open Sat. evenings.

Halifax: Halifax Planetarium, Nova Scotia Museum, Summer St., B3H 3A6, (902) 429-4610, located at Sir James Dunn Building, Dalhousie University. Open by reservation only.

ONTARIO

Hamilton: McMaster Univ. Planetarium, 1280 Main St. West, L8S 4M1, (416) 525-9140, 24' dome theatre. Open by reservation.

Ottawa: National Museum of Science & Technology, 1867 St. Laurent Blvd., K1G 5A3, (613) 991-9219, exhibits, observatory with 15" refractor. Observing every Tues. evening (in French) & every Wed. & Thurs. evening (in English) during July & August.

Sudbury: Science North Science Center, 100 Ramsey Lake Road, P3E 5S9, (701) 522-3701, exhibits, interactive Starwall, solar observatory. Open daily.

Toronto: David Dunlap Observatory, Box 360, 123 Hillsview Dr., Richmond Hill, L4C 4Y6, (416) 884-2112, 1.9-metre reflector. Tours Tues. mornings & public observing Sat. evenings, both by reservation only.

Toronto: McLaughlin Planetarium, Royal Ontario Museum, 100 Queen's Park, M5S 2C6, (416) 586-5737, 75' dome theatre, laser shows, exhibits. Open daily in summer. Program info. line: 586-5736.

Toronto: Ontario Science Centre, 770 Don Mills Road, M4C 4M3, (416) 429-4100, extensive science exhibits, 24' dome planetarium. Open daily.

QUEBEC

Montreal: Dow Planetarium, 1000, St. Jacques Ouest, H3C 1G7, (514) 872-4530, 65' dome theatre. Open daily. Alternating schedule of French and English programs.

Notre Dame Des Bois: Mont Megantic Observatory, Chemin de Lamontagne, J0B 2E0, (819) 888-2822, 63" reflector. Open daily in summer.

SASKATCHEWAN

Regina: Saskatchewan Science Centre, Winnipeg St. & Wascana Dr., P.O. Box 5071, S4P 3M3, (306) 352-5811, interactive science exhibits. Open Tues.–Sun. & holiday Mondays, daytime only. Program info. line: 352-5811.

Saskatoon: Observatory, University of Saskatchewan, S7N 0W0, (306) 966-6396, 6" Clark refractor, exhibits. Open Saturday evenings. Program info. line: 966-6429.

North American Organizations

American Association of Variable Star Observers, 25 Birch Street, Cambridge, MA, 02138, (617) 354-0484, Janet Mattei, Founded 1911, 1,100 members. 80th Annual Meeting Oct. 25–27.

American Astronomical Society, 2000 Florida Avenue N.W., Suite 300, Washington, D.C., 20009, (202) 328-2010, Peter B. Boyce.

American Lunar Society, P.O. Box 209, East Pittsburgh, PA, 15112, (412) 829-7455, Francis Graham, Founded 1982, 94 members, Observatory with 7" refractor.

American Meteor Society, Department of Physics-Astronomy, SUNY — Geneseo, Geneseo, NY, 14454, (716) 245-5282, David Meisel, Founded 1911, 50 members. Also via electronic mail: Bitnet MEISEL@GENESEO.

Amateur Satellite Observers, HCR 65, Box 261-B, Kingston, AR, 72742, Jim Hale.

Association of Lunar and Planetary Observers, P.O. Box 143, Heber Springs, AR, 72543, (501) 362-7264, Harry Jamieson, Membership Secretary, Founded 1947, 710 members. Annual convention July 8–12 at La Paz, Baja California Sur, Mexico.

Astronomical League, 6235 Omie Circle, Pensacola, FL, 32504, (904) 477-8859, (904) 484-1152, Merry Edenton Wooten, Founded 1948, 11,400 members. Hosting ALCON 91 National Convention Aug. 7–9 in Boston.

Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA, 94112, (415) 337-1100, Andrew Fraknoi, Founded 1889, 7,000 members.

Astronomy Day Headquarters, Chaffee Planetarium, 54 Jefferson SE, Grand Rapids, MI, 49503, (616) 784-9518, (616) 456-3987, Gary Tomlinson, Founded 1973. Astronomy Day resource materials available.

Aurora Alert Hotline, 25 Manley Drive, Pascoag, RI, 02859, (401) 568-9370, David A. Huestis, 100 members.

Earthwatch, Box 403, Watertown, MA, 02272, (617) 926-8200, Blue Magruder, Founded 1971, 45,000 members. Sponsors scientific field research worldwide.

Group 70/Large Amateur Telescope Project, 2331 American Avenue, Hayward, CA, 94545, (415) 969-6869, Russ Thomas, PR/Development.

International Amateur-Professional Photoelectric Photometry, Dyer Observatory, Vanderbilt University, Nashville, TN, 37235, (615) 833-8878, (615) 373-4897, Douglas Hall, Founded 1980, 950 members. Daytime phone number: (615) 373-4897.

International Dark-Sky Association, 3545 North Stewart, Tucson, AZ, 85716, David Crawford. Promotes awareness of light pollution problem.

International Occultation Timing Association, P.O. Box 7488, Silver Spring, MD, 20901, (301) 495-9062, David W. Dunham, 300 members.

International Planetarium Society, Hansen Planetarium, 15 South State Street, Salt Lake City, UT, 84111.

National Deep Sky Observers Society, 1607 Washington Boulevard, Louisville, KY, 40242, (502) 426-4399, (502) 561-6103, Alan Goldstein, Founded 1976, 100 members.

National Space Society, 922 Pennsylvania Avenue SE, Washington, D.C., 20003, (202) 543-1900, Aleta Jackson.

Problicom Sky Survey and Nova Patrol, 1940 Cotner Avenue, Los Angeles, CA, 90025, (213) 478-2526, Ben Mayer, Founded 1974, 200 members. Free quarterly newsletter – send 4 SASEs.

Royal Astronomical Society of Canada, 136 Dupont Street, Toronto, Ontario, Canada, M5R 1V2, (416) 924-7973, Founded 1890, 3,000 members. Local Centres across Canada. Annual General Assembly May 17–19 in Vancouver, B.C.

Small Scope Observers Association, 4 Kingfisher Place, Audubon Park, NJ, 08106, (609) 547-9487, Robert Browning, Founded 1986, 116 members.

Society for Scientific Exploration, P.O. Box 3818, Charlottesville, VA, 22903, (804) 924-4905, L.W. Frederick.

Society of Amateur Radio Astronomers, 247 North Linden St., Massapequa, NY, 11758, (516) 798-8459, Vincent Caracci, Founded 1981, 150 members. Annual conference June 10-12 at Green Bank, WV.

Spaceweek National Headquarters, 1110 NASA Road 1, #100, Houston, TX, 77058, (713) 333-3627.

Sunsearch Supernova Patrol, 14400 Kolin Avenue, Midlothian, IL, 60445, (708) 396-1499, Steve H. Lucas, Founded 1985, 25 members.

The Meteoritical Society, Department of Geological Sciences, University of Tennessee, Knoxville, TN, 37996, Founded 1933, 850 members.

The Planetary Society, 65 North Catalina Avenue, Pasadena, CA, 91106, (818) 793-5100, Susan Lendroth, Founded 1980, 125,000 members.

Webb Society (North America), 1440 S. Marmora Ave., Tucson, AZ, 85713-1015, (602) 628-1077, Ronald J. Morales, Founded 1967, 200 members (North America).

Western Amateur Astronomers, 163 Starlight Crest Drive, La Canada, CA, 91011, Stephen Edberg.

World Space Foundation, P.O. Box Y, South Pasadena, CA, 91031-1000, (818) 357-2878, Jack Child.

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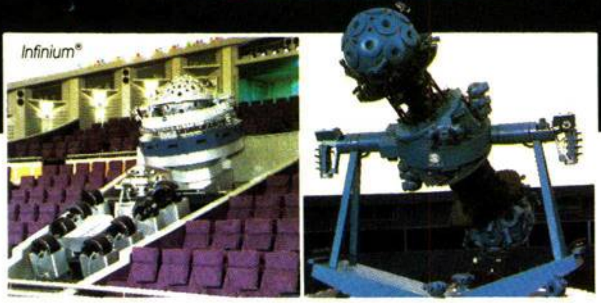

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